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The New Zealand Electronics Institute

Though this country is little more than a hundred years old, one of the most remarkable things about its development has been the progressive spirit in which current advances in engineering and applied science have been regarded. Our major undertakings, such as railways, telegraph and telephone services, roading, the provision of electric power, and public utilities generally, have always known the benefits due to the possession of the services of engineers and technicians of the highest calibre.

Because electronics is one of the newest branches of applied science, and itself has made such phenomenal strides since its beginnings early in the century, it is only recently that it has come to be recognised apart from the wider sphere of electrical engineering, as can be seen from the comparatively recent date of the formation of such bodies as the British Institute of Radio Engineers. Strangely enough, such recognition of electronics has come in this country several years later than was the case in England, and especially in the United States of America, and this in spite of the fact that its most important subdivision—that of radio—has been in constant development here for so long.

It is particularly gratifying, therefore, to see the formation of a New Zealand Electronics Institute. For too long now have radio men in this country felt the need of such a body, for, in spite of the comparatively large numbers engaged in the various technical aspects of the subject, so far no means have been provided for unifying their interests. The most important function of the newly-formed Institute will be to achieve professional recognition for those engaged in electronic work. To date, however, the only qualifications generally obtainable in this country (apart from membership of the I.E.E. and Brit.I.R.E.) are the Technical Certificate in Broadcasting and the Registered Serviceman's Examination. The latter is of too low a standard to be of much use to the man who wishes to be well qualified in electronics, while the former, though equal in standard to the theoretical portion of the P.M.G. First-class Wireless Operator's Licence, is too circumscribed in its application. Between these two examinations and the post-graduate course in electronics provided by the Engineering School at Canterbury University College, is a very wide gap indeed.

It is in bridging this gap that the New Zealand Electronics Institute will be able to play such an important part. As have the overseas institutions, so the Institute has a graded membership scale. Its constitution provides for an Admissions Committee, whose purpose will be to see that aspiring entrants are admitted to the grades most suitable to their attainments. If this Committee is composed of men of the highest standing in the profession, if before it commences to operate it acquires support in principle from the radio industry and from those Government Departments directly concerned, and, furthermore, if as qualifications for entry, it sets up a graded series of examinations bridging the gap between the Registered Serviceman's Examination on the one hand and the B.E. (Electrical) on the other, the worker in any branch of electronics will have available a series of qualifications recognised by all the interested authorities. Then there will be an incentive such as does not exist to-day for radio men to obtain knowledge of their work in organised channels. When this has become a reality, these men will obtain professional status according to their attainments, and with this will come all the advantages accruing to such status.

The New Zealand Electronics Institute already has the way partly paved towards this desirable end. The rest of the road may not be easy to build unless the Institute is adequately supported from the beginning, and unless its problems are tackled in the right way. The important thing at this juncture is that the Institute has been formed and a start made.

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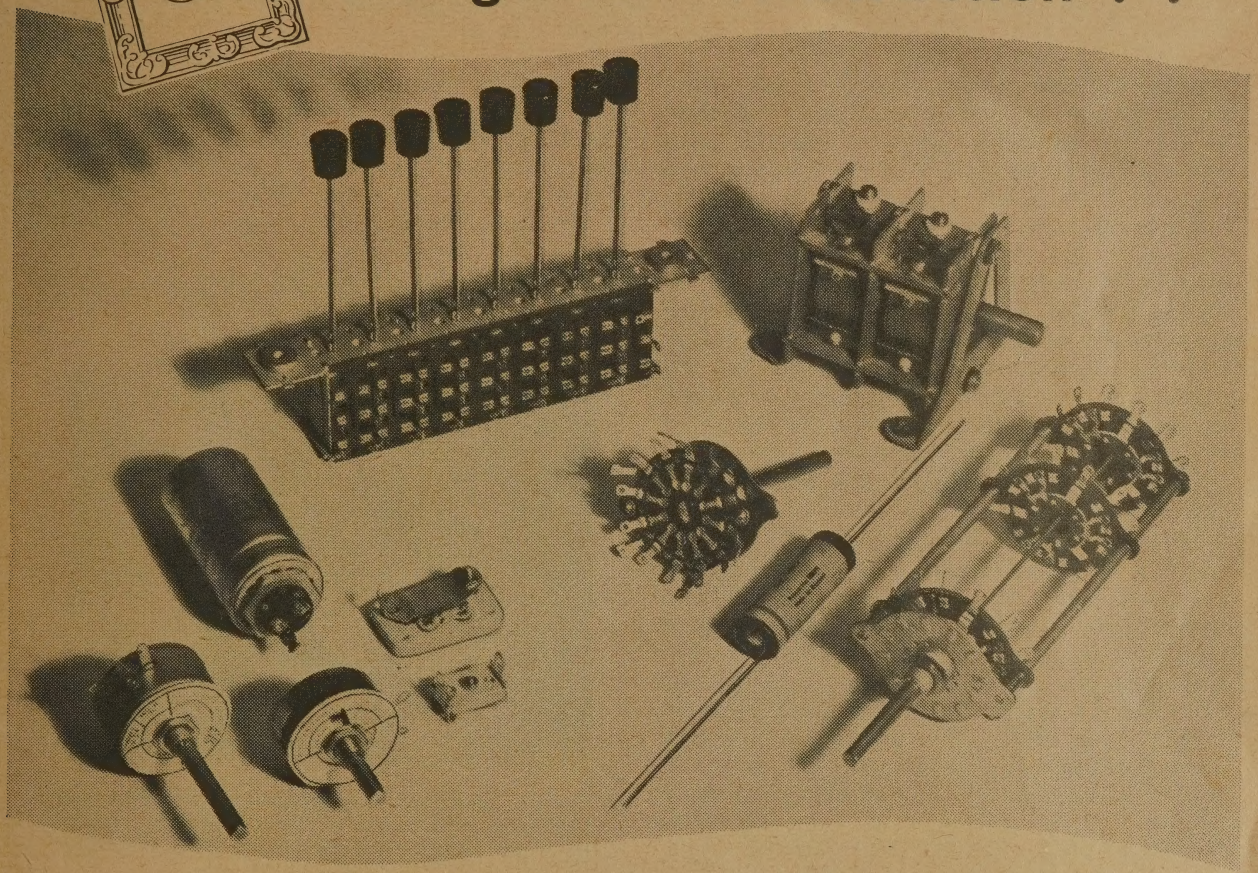

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RADAR

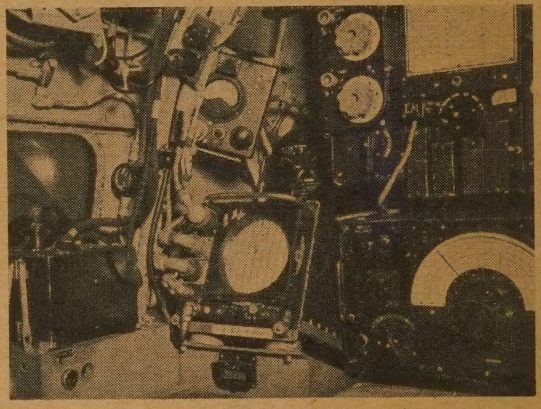
FISHPOND

Used as a radar proximity warning device on Britain's bomber aircraft, Fishpond assisted materially in the protection of crews and aircraft from enemy attack.

With the rapid strides made by British scientists in the development of radar and the application of new techniques in radar warfare, many problems associated with strategic bombing were overcome, and the efficiency and accuracy of the bombing offensive against the enemy improved. Equipment was developed to give considerable aid to navigation and bomb aiming, but it was obvious that any apparatus which would assist in the protection of aircraft crews must, of necessity, be of the highest importance. It was then that radar, with its amazing versatility, was adapted to function as a proximity warning device to warn our bomber crews of the approach of enemy aircraft, and it was for this purpose that Fishpond came into being.

Fishpond is an integral part of H_2S for, in effect, it utilises that portion of the information displayed on the H_2S screen which can be used for no other purpose than height finding or proximity warning. We have outlined the H_2S system in the September issue of *Radio and Electronics*, but some further information on this system is necessary before the fundamental principle of Fishpond is understood.

It is obvious that the first echoes to be received by the H_2S receiver are those from the terrain immediately below the aircraft. These and other echoes of varying ranges and amplitudes combine to make a map-like presentation of terrain within the service range of H_2S. For the purpose of an explanation of Fishpond, we will assume that the beginning of the H_2S P.P.I. radial time base is the exact centre of the tube, and that the transmitter pulse will show a bright spot at the start of the time base sweep. No more echoes will appear along the time base until such time as ground returns are received. These will appear as a circle on the P.P.I.—**the distance from the centre of the P.P.I. to the ground returns corresponding in range to the altitude of the aircraft.** This information is an important attribute of H_2S, for not only does it function as a radar altimeter, but this measurement is necessary for an accurate calculation of the ground range of a target. It will be realised that measurements of aircraft altitude and ground range are necessary to calculate the release point of the bomb. The H_2S indicator has, in addition to the P.P.I., a range tube. This tube is a normal "A" scope C.R.T., and is used to line up the range markers of the set to measure the range of the ground echo. The dial which controls the marker is calibrated in altitude so that when the marker is set to the ground echo, the actual height of the aircraft is read directly from the dial.



In the centre of the picture is the Fishpond Indicator fitted to the Wireless Operator's Table. All other equipment shown is for radio communications.

Fig. 2 shows the echoes as seen on the H_2S range tube and represents the transmitter pulse at A, the first ground returns at B, and a built up area at C. The aircraft is assumed to be at an altitude of 20,000 feet. It is obvious that no echoes can possibly be seen between A and B, as under normal conditions the first echoes which can be received are those from the ground. This point is the main feature in the operation of Fishpond, for any echo seen between A and B must of necessity be from another aircraft in the vicinity.

It is important to note that the proximity warning of Fishpond is restricted to the height of the aircraft, for it will be readily seen that any echo from another aircraft which is at a greater

range than the altitude will be lost in ground returns or other echoes. As the H_2S aerial system is fitted to the under surface of the aircraft, it is apparent that no echoes can be received from above the aircraft, for the transmitter energy will be screened by the aircraft fuselage and wings.

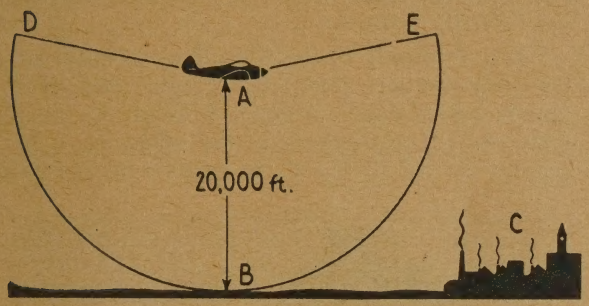


Fig. 1

This is the one disadvantage of Fishpond, but its other advantages warrant its use for proximity warning from any direction other than immediately above. Reference again to Fig. 1 will show that the warning area of Fishpond is that space enclosed by D.B.E.—the limit of detection above the aircraft being about 10 degrees above the horizontal position of the aircraft. As the scan of H_2S is through a sweep of 360 degrees, Fishpond will give warning through the same sweep. Further, the whole of the H_2S P.P.I. is "floating" on the gyrocompass, which means that irrespective of the heading of the aircraft, the top of the screen will always be north and the bottom south. This, of course, will have the same effect for Fishpond, which means that the exact direction of approach of another aircraft can be determined. There is, however, no means of indicating whether the approach is from above or below, but the fact that range and bearings can be found is very valuable information. For reasons related to radar bombing procedure, the transmitter pulse is usually not shown on the P.P.I. and the aircraft position corresponds to the first ground returns. In addition, the P.P.I. screen is only 5 in. in diameter, so that not much space is allowed in which to observe echoes between transmitter pulse and ground returns. For these two reasons, it was found necessary to use another P.P.I. tube in parallel with the H_2S as the Fishpond indicator. Furthermore, the radial time base was "expanded" so that the entire screen area of the second P.P.I. would display only signals up to the maximum service altitude of the aircraft. Apart from this one feature, all other functions of the H_2S P.P.I. are shown on the Fishpond P.P.I. The Fishpond indicator was fitted to the wireless operator's table, and it was his duty to maintain a careful watch on the screen and relay his observations to

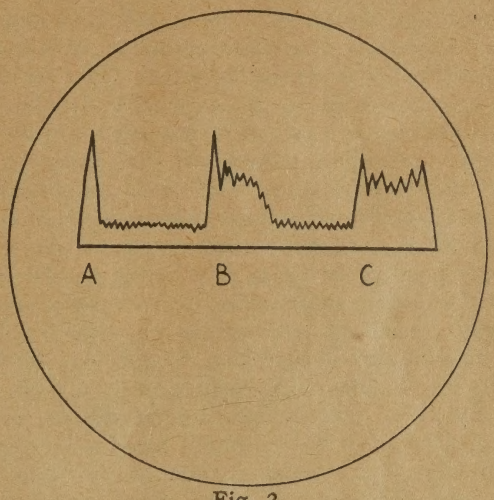


Fig. 2

the crew by means of the aircraft inter-communication set.

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A COMPACT 4½ WATT GRAMOPHONE AMPLIFIER

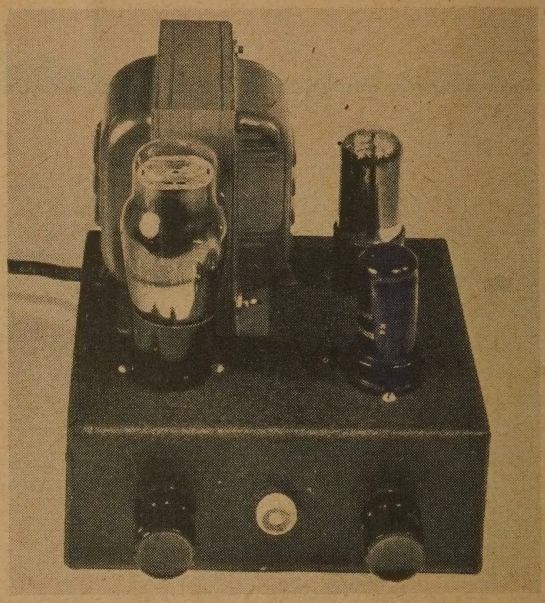
There was published in the April issue of this journal the design of a push-pull 6A3 amplifier capable of some ten watts output of high quality. However, not everyone wishes to build an amplifier as powerful or as expensive as this one. It is still recognised, of course, that for the best quality, push-pull triodes are the thing to use, but the fact remains that such amplifiers are more expensive than those employing pentodes or beam tubes. If only small power is required, a single pentode or beam tube is the logical choice for the output stage, since by the use of modern negative feedback circuits, the one-time bug-bears of high distortion and poor loudspeaker damping may be removed. A beam power tetrode, such as the 6V6, with proper circuit design, can be made to deliver its maximum rated power output with very low distortion, and at the same time to damp out loudspeaker resonance as effectively as does a triode. Thus, although triodes in push-pull are for any power output the sine-qua-non as far as quality is concerned, the use of a single beam tube with negative feedback is a matter of practical economics where a power of no more than three or four watts is required.

THE CIRCUIT

The present amplifier was designed with these considerations in view. It employs a well-tried circuit which is, however, not very often encountered. In most cases where the 6V6 is used as a single-ended output stage—namely, in the majority of domestic receivers—the circuit given here would require an extra valve to be used over and above the usual number. Thus, the usual five-valve receiver would became a "six," purely for the purpose of providing a good negative feedback circuit, and therefore better audio quality. This is obviously not a payable proposition for the set manufacturer, as it would make a considerable increase in his production cost, but does not prevent the circuit from being admirably suited to the purpose in hand.

The first stage is a 6SJ7 used as a resistance-coupled voltage amplifier. With the circuit constants shown, this tube has a gain of a hundred times, so that with no negative feedback it would be possible to load the 6V6 to full output with an input of only 0.125 volts. This amount of gain would be much too high for normal purposes were it not for the introduction of negative feedback over the 6V6 stage.

The feedback is introduced by connecting a 0.5 meg. resistor from the "high" end of the output transformer primary through C_6 to the plate end of R_6, which is the 100k. plate load resistor for the 6SJ7. C_6 is shunted by the 500k.



GENERAL VIEW OF THE AMPLIFIER
The control on the left is the bass boosting pot., while the volume control is on the right.

pot. R_8, which acts as a bass-boosting control, whose action is to be described. In this way, output voltage (or rather a portion thereof) from the 6V6 is applied across the plate load resistor of the 6SJ7. Since the plate circuit of this tube is coupled through to the grid of the 6V6, the feedback voltage is also applied to the grid of this tube. In this circuit, the degree of negative feedback is controlled by the relative values of R_5, R_6 and R_7. Since R_5 and R_6 are chosen from normal resistance-coupled amplifier practice, this leaves R_7 as the component actually exercising control over the feedback. In this case R_7 has been chosen to give a gain reduction factor of 3. This means that for a given output, three times as

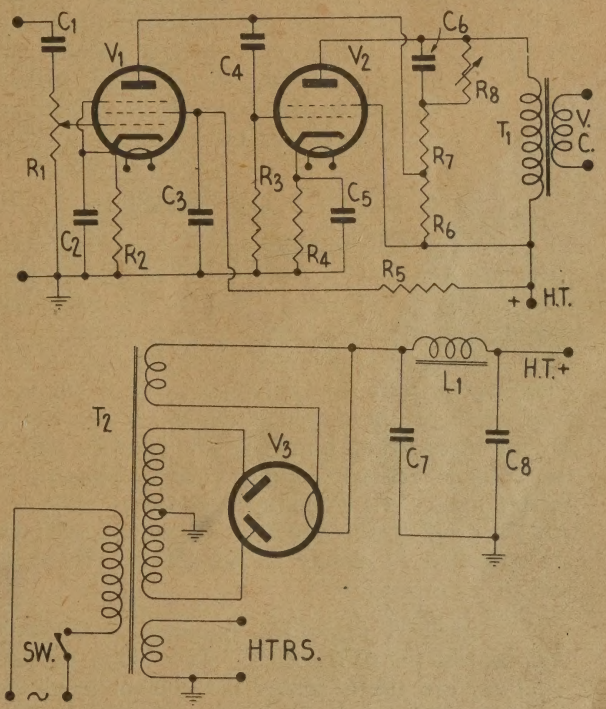
much input voltage must be supplied as compared with the same circuit with the feedback disconnected. It also means that for a given output, distortion is a third of that which would be present without feedback. From the above, it is clear that full output with the feedback applied is obtained with somewhat less than 0.5 volt input. Thus, in spite of the presence of quite heavy feedback, the amplifier still has an overall gain more than sufficient for most purposes.

BASS BOOST CONTROL

We have called R_8 a bass-boosting control rather than the somewhat overworked "tone-control" because the name exactly describes its function. The variable resistor R_8 is shunted across the condenser C_6, and has a variation of 0–500k. ohms. When the control is turned so that C_6 is short-circuited, the negative feedback is equally effective at all frequencies, since the feedback network now contains only resistors. This means that there is the same amount of feedback at all audio frequencies, so that as far as the valves are concerned, the response of the amplifier will be level from quite low frequencies to about 20,000 c/sec. But when R_8 is turned so that there is the full 500k. shunting C_6, the situation is somewhat different. In this case, R_8 is so high in value that it may virtually be regarded as an open circuit, leaving C_6 in series with R_7 and R_6. Now this network will pass high and medium audio frequencies with little or no attenuation, but at low frequencies there is a dropping off in the voltage output of the network at the point where R_6 and R_7 join. This dropping off is just as if C_6 were a grid-coupling condenser that is too small to pass enough low frequency voltage to the next stage, and occurs for exactly the same reason. In this case, the drop in frequency response causes less voltage to be fed back to the 6V6 grid at lower frequencies than is fed back at medium and high frequencies. The amplifier, therefore, has a higher gain for low frequencies than when C_6 is short-circuited by the control. The action of R_8 is therefore to leave unaffected the high- and medium-frequency response of the amplifier, but to give a controllable amount of extra low frequency gain. It is therefore a true bass-boosting circuit. This has the great advantage over normal "tone-control" circuits that whatever bass response is required, working the control does not attenuate the high-frequencies, nor does it allow the spurious distorted high frequency response to be produced, typical of pentodes and beam tetrodes working without negative feedback.

CONSTRUCTION

The layout of the amplifier is very compact, yet it is not over-crowded, and offers no mounting or wiring difficulties. The chassis measures 6½ in. x 6 in. x 2 in., the 6½ in. sides forming the front and back. As can be seen from the photograph, the 6SJ7 and 6V6 are placed along the right-hand side of the chassis; the power trans-



R_1 = 1 meg. pot.
R_2 = 500ω.
R_3, R_5, R_7 = 500k.
R_4 = 250ω.
R_6 = 100k.
R_8 = 500k. pot.
C_1, C_4 = 0.1μf. 600v.
C_2, C_5 = 50μf. 25v. Electro.
C_3 = 0.5μf. 600v.
C_6 = 0.001 mica.
C_7, C_8 = 16μf. 450v. Electro.
T_1 = Output Transformer, 5000ω to voice-coil
T_2 = Power Transformer 385-0-385v. 80ma., 6.3v. 3 amp., 5v. 2 amp.
V_1 = 6SJ7.
V_2 = 6V6-GT.
V_3 = 80.
L_1 = 2000ω speaker field.

former occupies the back left-hand corner and the rectifier the front left-hand corner. The three valve socket holes have their centres 1½ inches from the nearest sides. The three holes in the front on which are mounted the volume control (at the right), the input socket and the base-boost control are 1 inch from the top of the chassis. The input socket is in the dead centre of the front, while the two controls are each mounted 1½ inches in from their respective sides. The holes for the speaker plug and the power lead cannot be seen in the photograph, since they are in the back of the chassis. The former is directly behind the 6V6, i.e., 1 inch from the chassis top and 1½ inches from the side, while the latter is in a similar position, behind the power transformer.

MOUNTING OF PARTS

In wiring up the amplifier, a combination of point-to-point and resistor strip mounting was used for the small parts. Most of the latter are mounted on a piece of resistor strip having nine lugs. The strip is mounted along the side of the chassis next to the two amplifier tubes. The only small parts in the amplifier circuit proper which are not mounted on it are the two potentiometers, the cathode resistors and bypass condensers of the two stages, the coupling condensers C_1 and C_4, and the 6SJ7 screen bypass condenser C_3. These are mounted as closely as possible to the valve sockets concerned.

The feedback network is mounted on the strip lugs nearest the 6V6 socket. Two wires, twisted together, are taken across the chassis from the feedback condenser to the bass-boost control. The manner in which this twisted pair is run is the only really important point about the layout of the wiring. If this pair, which carries audio voltage at a quite high level, is run close to the input wiring to the 6SJ7, the amplifier as a whole may oscillate at some super-audible frequency, causing overloading and distortion at very low signal outputs. However, by placing this lead in such a way that it does not approach the input wiring, this potential cause of trouble can be eliminated.

OPERATION

A 0.1 μf. condenser has been wired into the input circuit so that where the amplifier is used to follow a radio tuner, no blocking condenser will be necessary external to the amplifier. If the amplifier is to be used with a gramophone pick-up only, this condenser could be omitted altogether. In order to use the amplifier with a low level microphone, an extra stage will be necessary, which could be built as a separate unit, power being derived from the amplifier itself. This amplifier is very simple to construct, and the one "bug" mentioned above is the only potential source of trouble. In spite of its small size and simplicity, the amplifier is capable of almost as good quality (within its power-handling capability) as the triode amplifier described in the April issue of *Radio and Electronics*. It should be remembered, however, that the quality of reproduction obtained will be directly proportional to the quality of the pick-up, tuner, and loud speaker used with it. If the best possible results are desired, it is false economy, even with a small amplifier such as this, to use anything but the best pick-up and speaker than can be afforded. If the latter are used, the quality obtainable will be surprising—certainly not very far behind that of a much more expensive amplifier having the same power output.

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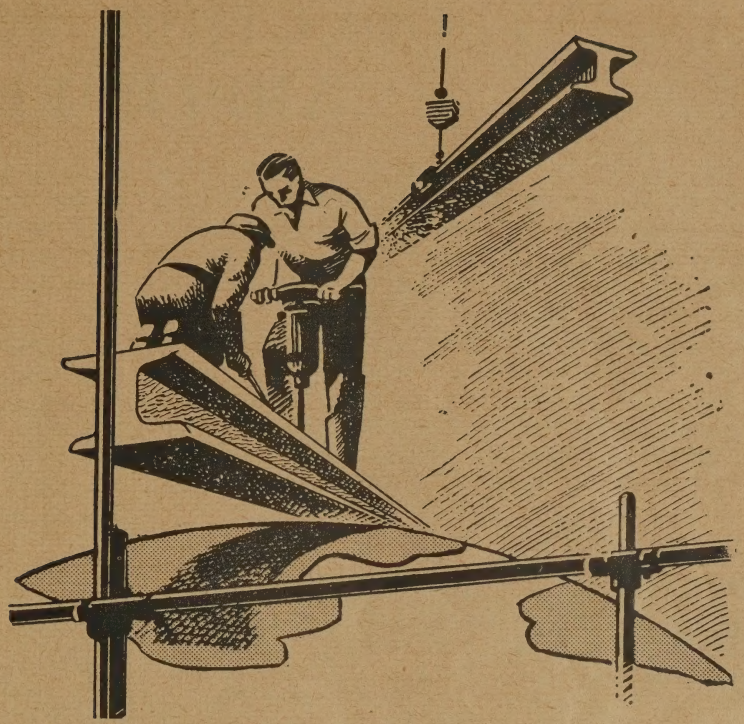

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AN INTRODUCTION TO WIDE-BAND AMPLIFIERS

PART I.

The need for really wide-band amplifiers first arose during the development of high-definition television. Since that need was first apparent, an enormous amount of work has been put into the design of special valves suitable for use in these amplifiers, and a great deal has been learned about the mechanism of this type of amplification. It is possible, with present-day tubes and circuits, to build amplifiers with almost any desired frequency or phase characteristic, even to the extent of obtaining uniform amplification

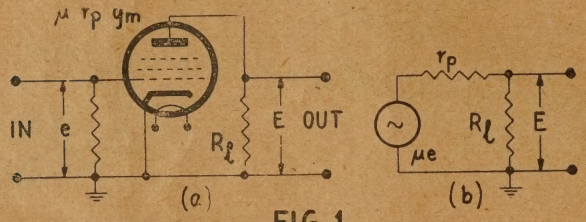

FIG. 1

over a range of 10 c/sec. to 10mc/sec—a range of a million to one! This is an extreme case, and even now would not be an easy design problem, but serves as an example of what can be accomplished.

NOT ONLY FOR TELEVISION

Although television was the spur which forced the development of wide-band amplifiers, it is by no means the only branch of the science of radio which makes use of them. For instance, had wide-band technique not been in an advanced state of development at the beginning of the recent war, it would have been quite impossible for radar (or any other system using narrow pulses) to have been brought to its present state of perfection. However, it is not with the idea of allowing everyone to become his own radar designer that we present this article. A knowledge of wide-band amplifiers is of very great assistance to anyone who is interested in audio amplifiers or oscilloscopes, for instance. The audio amplifier itself is the direct ancestor of all video amplifiers, for it is itself a wide-band amplifier, and a study of the technique of video amplifiers can give the audio enthusiast a far greater insight into the possibilities and limitations of audio amplifiers. Nowadays, such things as pulse-modulation and the rapid testing of audio amplifiers by means of square-waves must be interpreted in the light of wide-band amplification. Resistance-capacity audio oscillators and the design of oscilloscope circuits require a knowledge of this subject, if not its direct application.

Enough has now been said to indicate that the subject of this article is not necessarily of interest solely to the television or radar engineer, and, as the subject is in itself an interesting one, it is felt that a large number of our readers will be well repaid by at least a simple exposition of it.

AUDIO AMPLIFICATION

The basis of our discussion is the resistance-coupled audio amplifier, for, as mentioned above, this circuit is the ancestor of all wide-band amplifiers. Fig. 1 (a) shows the basic circuit of such an audio stage. For purposes of discussion, we have drawn all the tubes in these diagrams as pentodes. The simple stage of Fig. 1 (a) has been shown to be entirely equivalent at low and medium audio frequencies to the even simpler circuit of Fig. 1 (b). Here, the valve has been replaced by its plate resistance rp, in series with an imaginary generator whose output voltage is μ times the input voltage e. As in the actual circuit, the output voltage E is taken from the load resistance Rl, so that from the equivalent circuit of Fig 1 (b), it is readily seen that the output voltage E is equal to

$$\mu e \times \frac{Rl}{Rl + rp}$$

This follows from the simple voltage divider action of rp and Rl. Thus, the gain of the stage at low and medium frequencies is: —

$$G = \frac{E}{e} = \frac{\mu e}{e} \frac{Rl,}{Rl + rp} = \frac{\mu Rl}{Rl + rp}$$

which is the well-known formula, applicable to any tube, either triode or pentode. Before proceeding with the argument, it is necessary to point out a useful simplification of this relation. This simplification applies to the case where rp is very much greater than Rl, so that in practice it can be used only in referring to pentode stages.

If the above condition holds, namely rp>> Rl, the formula simplifies to:—

$$G = \frac{\mu Rl}{rp} = gm.Rl.$$

Thus, in a pentode resistance coupled stage, the gain is directly proportional both to the mutual conductance of the tube and to the value of the load resistor. This is the state of affairs for the circuit of Fig. 1, at low and medium frequencies, say, below 500 c/sec.

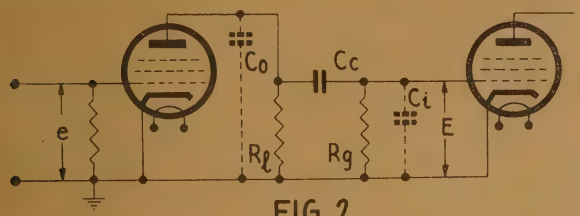

FIG. 2

LOW AND HIGH FREQUENCIES

Unfortunately, the simple state of affairs shown by Fig. 1 does not occur in practice, either for very high or very low frequencies. The reason for this can be seen from Fig. 2. This circuit shows the original stage resistance-capacity coupled to the next stage. Since the output voltage of the first stage is really the voltage delivered to the grid of the following stage, it has been shown at that point on the new circuit. In addition to the coupling components Cc and Rg, there are shown two new capacities, Co and Ci. These are respectively the output capacity of V_1 and the input capacity of V_2.

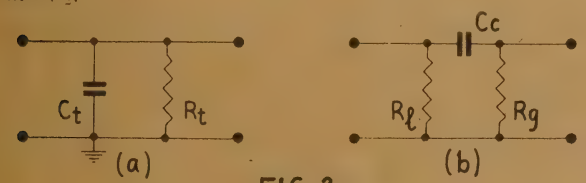

FIG. 3

High Frequencies:

Now Cc has practically no effect on the operation of the amplifier at high frequencies, because its reactance is so low at these frequencies that it can be regarded as a short circuit. However, the capacities Co and Ci are shunted across Rl and Rg respectively, so that each will have the effect of partially bypassing high frequencies to earth. The higher the frequency, the more effective is the bypassing effect of these capacities. In this way it can be seen that the whole coupling network between the plate of V_1 and the Grid of V_2 can be regarded at high frequencies as exactly equivalent to Fig. 3 (a). In this, Rt represents the value of Rl and Rg in parallel (Cc having no effect) and Ct is the sum of Co and Ci. This simplification having been made, it can be seen that at medium frequencies, the small capacity Ct has no effect on the output voltage (and therefore on the amplification of V_1), because its reactance is so high compared with the value of Rt that no shunting occurs. However, as the frequency is increased, the reactance of Ct becomes lower and lower in comparison with the value of Rt, and an appreciable bypassing effect comes into play. This progressively decreases the output voltage as the frequency is raised, while ultimately a point is reached where there is no output voltage at all, and the stage gain is zero.

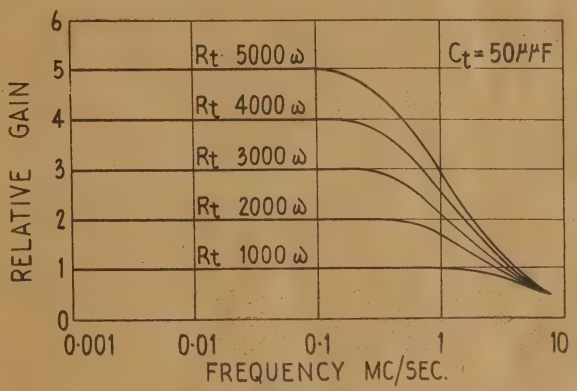

FIG. 4

Low Frequencies:

As previously mentioned, Co and Ci are too small to have any effect on the low-frequency operation of the stage. Thus, the only extra factor introduced into Fig. 2 on the low frequency side is the coupling condenser Cc. Thus, the equivalent circuit of Fig. 3 (b) is valid at low frequencies. Here, the reactance of Cc becomes progressively higher the lower the frequency, so that Cc and Rg act as a voltage divider, and the grid of V_2 receives only a portion of the amplified voltage developed across Rl. In any given cases, the falling-off at low and high frequencies discussed above, takes the forms given in Figs. 5 and 6, so that these can be considered to be the high and low-frequency response curves of any resistance capacity coupled amplifier stage. No specific frequencies have been shown on the diagrams, which will be useful when it comes to discussing the circuit values

used in practice. Without further consideration, however, it is obvious that the points at which the frequency response starts to drop off will be determined in any particular amplifier stage by the actual values of Co, Ci, Rl, and Rg.

SCOPE OF DISCUSSION

The above discussion is quite general in its application, and refers to *any* resistance-coupled stage, either triode or pentode. So far, the causes of the falling-off of the response curve both at high and low frequencies have been presented, without any reference to measures that may be taken to combat these defects. In audio amplifiers using triodes, the high-frequency effect does not come into play until well above the audio range, and, except in unusual circumstances, may be disregarded. In pentode audio stages, however, the load resistors sometimes

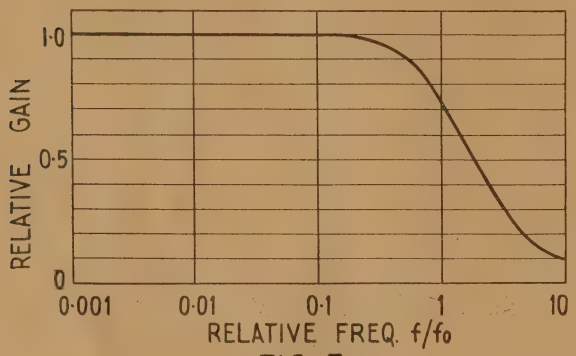

FIG. 5

used are high enough in value for the tube capacities to come into action at as low as 5000 c/sec., and means must be found for avoiding this if high-frequency response better than this is desired. Again, referring only to audio amplifiers, the low-frequency response can be made quite adequate with either triode or pentode stages by making the coupling condenser Cc large enough in relation to Rg.

However, when it is desired to extend the frequency range of an amplifier to both higher and lower frequencies than are normal for the audio range, special means must be found for doing this. First of all, we will consider the limitation at the high-frequency end, and one of the ways that can be used for obtaining a wide response band.

EXTENSION OF HIGH FREQUENCY RANGE

A mathematical analysis of the equivalent high-frequency circuit, Fig. 3 (a), is quite easy to perform, and leads to a very simple and useful conclusion, as follows:—*The high-frequency response drops to 0.707 of the mid-band response at the frequency where the reactance of Ct equals the value of Rt.*

For example, suppose that in a particular case Ct = 50 $\mu\mu f$. and Rt = 50,000 ohms. The reactance of 50 $\mu\mu f$. is equal to Rt (i.e., 50,000 ohms) at a frequency of 63 kc/sec. Thus, this stage would have a response equal to 0.707 of the mid-band response at 63 kc/sec. Since 0.707 of the maximum voltage output represents a drop of 3 db., we can say that the stage in question has a response flat within 3 db. up to 63 kc/sec.

This simple relationship indicates that one way of extending the high-frequency response of a resistance-coupled stage is to use a lower value of Rl, giving a lower value of Rt. In the case mentioned above, if the latter was reduced to a value of 10,000 ohms, the point for a 3 db. drop in response would be raised to 317 kc/sec.! This appears at first sight to give a very easy solution to the high-frequency problem. Within limits, this is true, but these limits are most important.

Firstly, if triodes are being used, the extent to which the frequency range may be extended by this means is severely limited, for a triode

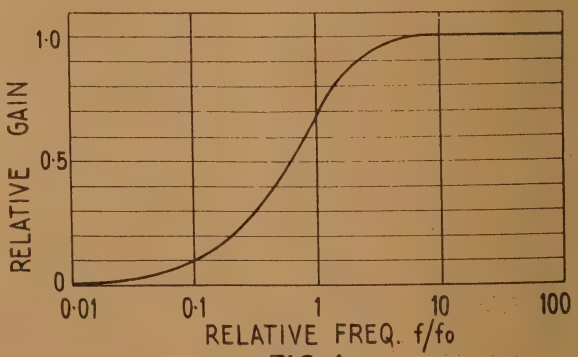

FIG. 6

must not be used with a load resistance of much less than twice its plate resistance if excessive distortion is to be avoided. The average small triode has a plate resistance in the region of 10,000 ohms, so that a load resistor of less than 20,000 ohms could not be recommended. In passing, it should be mentioned that, with triodes, Ci is much higher than with pentodes, owing to Miller effect. For these two reasons triodes are

(*Continued on page* 48.)

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This instrument is easily constructed, accurate and inexpensive. It uses a 0-1 ma. meter movement, yet has a sensitivity of 0-2 volts full-scale on its lowest range.

Most vacuum-tube voltmeter circuits published in the literature specify the use of a microammeter, which is costly, delicate, and sometimes difficult to replace. With this in mind, *Radio and Electronics* has designed a V.T.V.M. which uses only a 0-1 ma. meter movement, and yet has a maximum full-scale sensitivity of 2 volts. Higher ranges may be provided very easily, and the electrical design is such that very great overloads are impossible. It is hoped, therefore, that the present design will fill a rather long-felt want for servicemen and amateur enthusiasts. Although presented here in its simplest form—for D.C. measurements only—the circuit can form the basis of a quite elaborate meter for A.C. and D.C. measurements, with any desired frequency and voltage range. As the circuit stands, it may be used, without essential modification, as a very high-range ohm-meter with a mid-scale reading of five megohms. The input resistance of the meter is almost infinite on the 0-2 volt range, and is five megohms on all higher ranges.

THE FUNDAMENTAL CIRCUIT

The full circuit, including power supply, is shown in Fig. 2, but, for simplicity, the basic measuring circuit is given in Fig. 1. V_1 is essentially a triode amplifier with a resistive load, R_2, and an unbypassed cathode resistor, R_1. These resistors are so proportioned that the bias on V_1 is a little more than sufficient to prevent the flow of grid current from contact potential in the tube. In other words, the bias is arranged so that, with no input voltage, the tube is working near the top of the straight portion of its mutual characteristic. Thus, if a negative potential is applied to the grid of V_1 the plate current decreases. The voltage drop across R_2, therefore, decreases, and the plate voltage increases towards the potential of the H.T. + rail.

V_2 is a tube similar to V_1 in characteristics, and with a load resistor R_3 equal to R_2. R_4 and R_5 in series provide a means of biasing V_2 so that its plate voltage is the same as that of V_1. The variable section is necessary in order to compensate for slight variations in valves and resistors, so that R_5 forms the zero-setting control. Since with no input voltage to V_1, the plate voltages of V_1 and V_2 are adjusted to be equal, there can be no current through the meter M, which will read zero. When the above-mentioned negative voltage is applied to the grid of V_1, its plate voltage increases. Since the grid of V_2 is earthed, no alteration in grid voltage can occur, so that the plate voltage on this tube remains constant under all conditions. Thus, the application of a negative input voltage to V_1 results in the plate voltage of V_1 rising above the plate voltage of V_2; a potential is thus developed across the meter, and current flows through it and is measured. In the complete instrument, the meter shunt R_6 is employed as a convenient means of producing the correct full-scale meter reading on the 0-2 volt range. R_6 is necessary because, with a 250-volt power supply, as used here, the full scale sensitivity was approximately $1\frac{1}{2}$ volts with the meter used. The latter had a resistance of 50 ohms, but any 0-1 ma. meter that is likely to be used will give approximately the same sensitivity. R_6 will be further discussed in connection with calibration.

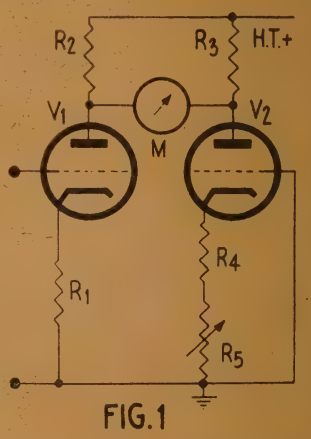

FIG.1

POWER SUPPLY

For a meter such as this to be successful, a regulated power supply is essential, but, apart from this, the power supply circuit used is slightly unconventional in that no smoothing choke is used. It is possible to dispense with this because, first, the current drain is quite light, secondly, because the balanced voltmeter circuit renders ineffective any hum voltages applied to the plate

circuits, and finally, because of the smoothing effect of the V.R. tubes. The only conventional filtering used is the 16μf. 450v. electrolytic condenser C_1. The transformer used is of the small 40 ma. instrument variety. The value of R_7 is such that the V.R. tubes draw approximately 20 ma. The current drain of the two measuring tubes is only 5 ma. with no input, dropping slightly as input is applied to V_1. It should be noted that the complete power supply is "floating." There is no direct connection to the metal chassis at any point, but the negative rail of the power supply is earthed to the chassis through C_2. The purpose of this is to allow both input leads to be insulated from the chassis, so that the meter may be used with both test leads at potentials above ground, there being then no possibility of shocks from the chassis of the meter being "up."

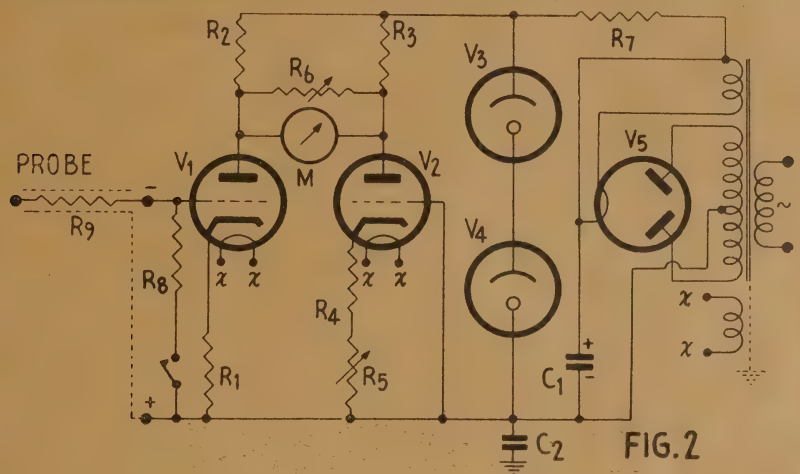

FIG. 2

$R_1 = 500\omega$.
R_2, $R_3 = 50$k.
$R_4 = 250\omega$.
$R_5 = 500\omega$ w-w pot.
$R_6 = 200\omega$ w-w pot.
$R_7 = 4500\omega$ 5w. w-w.
$R_8 = 200$k. (for 0-50v. range).
$R_9 = 5$ megs.

$C_1 = 16\mu f$. 450v. Electro.
$C_2 = 1\mu f$. 600v.
V_1, $V_2 = 6AC7/1852$, screen and suppressor tied to plate.
$V_3 = VR105/30$.
$V_4 = VR150/30$.
M = 0-1 ma. moving-coil meter.
Power Transformer = 300-0-300v. 40 ma.

CONSTRUCTION

Since the instrument is used for D.C. readings only, layout is not very important, and any convenient chassis arrangement may be used. The valves should be totally enclosed so that contact with the metal 6AC7 envelopes is impossible. The shell of these valves should be connected not to chassis, but to the negative power supply rail, as otherwise a high voltage would be developed between shell and cathode when the test leads are both at potentials above ground. It is important also that C_2 should be of 600-volt rating, for, should it break down, the voltmeter chassis will assume the potential of the positive test lead.

On the circuit diagram, R_9 has been shown as incorporated in the probe used for the negative test lead. There is a slight advantage in this on account of the filtering action to R.F. that might be induced in the lead under some circumstances, but the probe construction is not absolutely essential, although it is advisable. However, it *is* essential for the shielding of both test leads to be thoroughly insulated, since they will often be at high positive potentials when the meter is in use. R_6 and R_5 should preferably be mounted on insulating sheet, since, although the terminals of these potentiometers will normally be insulated from their case, this insulation is not necessarily intended for working at voltages up to 600, and a breakdown to chassis of any component in the meter must be avoided at all costs.

CALIBRATION

The accuracy of the meter can be as great as that of any instrument used as a calibration standard. The first step in the calibration is to adjust the 0-2 volt range. A source of voltage and a calibrating meter is required. The voltage

source can be two No. 6 dry cells in series, and the calibrating meter should be as good a one as can be obtained. The procedure is as follows:

(1) Connect a 2000-ohm potentiometer across the voltage source, and the calibrating meter between the moving arm of the potentiometer and the positive battery terminal.

(2) Connect the negative V.T.V.M. test lead to the moving arm of the potentiometer and the positive lead to the positive terminal of the battery.

(3) Turn the potentiometer until the calibrating meter shows zero volts.

(4) Turn on the V.T.V.M. and adjust R_5 until the meter reads zero. (About three minutes' warm-up period should be allowed.)

(5) Turn up the input voltage with the 2000-ohm potentiometer until the calibrating meter reads exactly two volts.

(6) Adjust R_6 until the V.T.V.M. reads exactly full scale.

The 2-volt range is now completely calibrated and R_6 will need no further adjustment. Calibration of the higher voltage range (or ranges) is carried out by providing, as before, a known source of voltage, read on the calibrating meter, and by adjusting the value of R_8 until the appropriate reading is indicated on the V.T.V.M. In the case of the prototype constructed in our laboratory, only two ranges were incorporated, the high one reading 0-50 volts. Thus, for the meter to read 50 volts full scale, one-twenty-fifth of the input voltage must be applied to the grid when R_8 is switched into circuit. Since R_9 is 5 megs., R_8 should therefore have a value of 208,300 ohms. Since this is a non-standard value, it will have to be made up by using two standard values in parallel. In this case, 1 meg. in parallel with 250k. gives a resistance of 200k. This value is not correct, but with the tolerance of 10 per cent. normally found with carbon resistors, any such combination will range from 190k. to 210k., so that the correct value is possible to obtain by using stock resistors. All that has to be done is to find three resistors of nominal values of 5 meg., 1meg., and 250k., which, when connected in the appropriate manner will give a voltage division of one-twenty-fifth. Calibration of the range is therefore purely a matter of trial and error until the correct voltage is indicated by the V.T.V.M. This scheme is far better than using a carbon potentiometer for R_8, since the latter's setting is more subject to change than is the value of the fixed resistors.

Ranges of 0-250 volts or even higher could be provided by choosing the correct resistors for the position of R_8, in conjunction with a known voltage source for calibration purposes.

USING THE METER

The meter may be used for any purpose where extremely high input resistance is necessary. It is most useful for checking actual voltages at high impedance points of a circuit, such as measuring A.V.C. voltage directly, in cases where trouble is suspected in this part of a set. With it, actual voltages between grid and cathode of self-biased valves may be measured, as can actual voltages at the plates and screens of resistance-coupled audio stages. It will therefore show up faults that a 1000-ohm per volt meter will not indicate, and should form a very useful adjunct to the service bench.

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SOME NOTES ON THE DESIGN OF AMATEUR-BAND RECEIVERS

Part 2

Image Response

In amateur superheterodyne receivers, one point which is often overlooked is that of image response. In any set which has one stage of tuned R.F. amplification ahead of the mixer, image response is ordinarily negligible on the 80-metre band, noticeable on the 40, and quite serious on 20 metres, assuming the usual I.F. in the vicinity of 465 mc/sec. In order to give really good image rejection on the 20-metre band, two stages of R.F. are necessary, and have become standard practice in the best communications receivers. It is not suggested that amateur receivers should necessarily be built to conform with the most stringent commercial requirements, but it is plainly advantageous that the closer they approach these requirements the better, other factors such as cost and ease of construction having been given due consideration. Notwithstanding, the problem of image response is well worth careful consideration, particularly when the congested state of the amateur bands is taken into account, for image responses add directly to the number of heterodyne whistles which can be heard in tuning over the band. In addition, signals completely outside the desired wave-band may be heard by means of image response, and amount to increased congestion from the viewpoint of an operator searching for true signals.

Since image response is a direct function of the ratio of the intermediate frequency to the signal frequency, it may be minimised by two methods—by increasing the selectivity at the signal frequency, or simply by raising the I.F. Unfortunately, I.F. transformers tuned to frequencies higher than 465 kc/sec. are difficult to obtain, and the use of a high I.F. such as 1500 kc/sec. severely limits I.F. gain and adjacent channel selectivity.

Thus, the line-up suggested above as being suitable for the best signal-to-noise ratio is not very good from the point of image response, since it includes no R.F. stage. However, if there is added an R.F. stage which uses a 6AC7/1852, the image response will be greatly improved and the signal-to-noise ratio degraded very little owing to the low noise properties of this valve. From the point of view of good signal-to-noise ratio and good image response, therefore, an excellent line-up for an amateur receiver would be: 6AC7 R.F., 6SN7 infinite-impedance mixer and oscillator, EF38 first I.F. and 6SK7 second I.F. This receiver would have very much better DX capabilities than many commercial communication receivers, and would be admirable for use on the 80, 40, and 20-metre bands. On 10 metres it would also be entirely adequate, except that image response might be somewhat poor on this band.

GAIN CONTROL

The question of gain control in communication receivers is one which, though outwardly simple, hides quite a number of problems.

(1) Strong Signal Distortion:

With all types of gain control, manual or automatic, sufficient range of control must be available, and at the same time a minimum of distortion must be introduced on strong signals. These requirements are mutually contradictory, since even modern variable-mu tubes have a limit to the signal that can be handled without excessive distortion. If the receiver is a multi-stage affair, there is a great danger of overloading the last I.F. stage, unless the control is staggered in such a way that this stage receives only a portion of the total control voltage. Although this principle is fairly well known in its application to A.V.C. systems, it should be realised that it applies equally to manual control circuits where grid bias variation is used. In this case, one-half to one-third of the total control voltage is the right proportion to apply to the last I.F. stage, the full control being given to all preceding stages. In the case of a receiver in which it is desired to use screen-voltage control, staggering is even more important, and may necessitate a quarter or less of the total control being applied to the last I.F. stage, or even leaving it un-controlled.

(2) Signal-to-Noise Ratio:

This factor, too, can suffer if the gain control is poorly designed for a high-sensitivity receiver. This is because all ordinary R.F. amplifier and mixer tubes suffer an increase in noise level as the grid bias is made more negative. Unfortunately, this degradation occurs more rapidly than might be expected if the R.F. stages are controlled, and can result in a decrease of as much

as 18 db. in signal-to-noise ratio for a signal increase of a hundred times. One way out of this difficulty is to control only the I.F. stages, but if this is done a poor control characteristic results, in combination with greater difficulty over strong-signal distortion.

(3) Cross Modulation:

Where a weak desired carrier lies adjacent to a strong undesired one, cross modulation is likely to occur if gain control takes place in the I.F. stages only. This indicates that an improvement under these circumstances can be effected by controlling only the R.F. stages. Unfortunately, doing this is in exact opposition to requirement (2) for best signal-to-noise ratio. However, communications receivers often provide separate R.F. and I.F. gain controls for this very reason. The operator can then choose his method of control to suit the reception conditions. Of course, the common method of controlling R.F. and I.F. tubes simultaneously, either manually or by A.V.C., is a compromise between these two conflicting factors. It may be mentioned at this point that in a receiver using a very low-noise "front end," gain control in one or two R.F. stages may not degrade the signal-to-noise ratio to any noticeable extent.

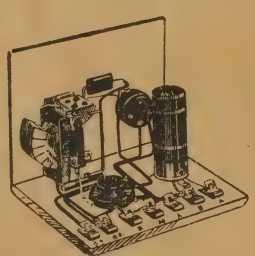
(4) Mistuning of R.F. and I.F. Circuits:

In spite of the low grid-plate capacities of modern R.F. pentodes, the gain in such stages causes the Miller effect to be appreciable. A detuning effect, therefore, occurs as the gain is controlled. The detuning in any one case will be a function of the L/C ratio of the input circuit of and the selectivity in this circuit. In medium and low selectivity arrangements, the effect will not be serious, but where many stages are controlled, it can be so. The standard cure for this trouble is to leave unbypassed a small portion of the cathode bias resistors in the stages concerned, but the receiver suffers a slight reduction in gain through negative feedback if this is done.

The above four points apply equally to manual or automatic gain control. Those which follow are concerned more especially with the latter.

(5) Effectiveness of A.V.C.:

By this is meant the degree closeness with which the receiver approaches the ideal of constant output for varying input. First, "simple" A.V.C. without voltage delay is ruled out completely, as this system decreases the sensitivity for weak signals, and does not give a very flat characteristic. For communication receivers a large delay voltage



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of 10 volts or so is a decided advantage, because the sensitivity remains undiminished for signals of up to 5 μv. or so, and the output is kept very flat (within say 10 db.) for signals from 5 μv. to 0.1 volt. In using a large delay voltage, a high amplitude is obtained at the 2nd detector and therefore at the last I.F. grid, so that this tube will have to be provided with partial control if strong signal performance is to be good.

(6) A.V.C. Worked by Interference:

If this effect occurs, as can be the case where audio selectivity is used for c.w. reception, an interfering station may not be audible and yet may work the A.V.C. This clearly undesirable effect will not happen if the selectivity actually used for the audible signal is comparable with that at the point where the A.V.C. voltage is derived. In case of high audio selectivity, it may be necessary to derive the A.V.C. voltage from the audio output rather than from the R.F. section of the set.

(7) A.V.C. Worked by the B.F.O.:

For best signal-to-noise ratio, the B.F.O. should always inject a signal at the 2nd detector rather larger than the R.F. signal voltage at that point. If some circuits are used, the B.F.O. under these circumstances will reduce the sensitivity by working the A.V.C. A quite normal circuit which minimises this effect is the one where the A.V.C. diode is fed from the primary of the last I.F. transformer, the B.F.O. injection taking place at the secondary of the same transformer.

RECEIVERS FOR THE HIGHER FREQUENCIES

All the above remarks apply generally to receivers for any of the amateur bands, but there are a number of factors which make a different approach to receiver design desirable when thinking of the bands above 14 mc/sec. in frequency. Much of the technique applicable to the lower frequency bands becomes of doubtful value when applied higher up. For example, losses, stray capacities, and ganging difficulties which are not particularly troublesome below the 14mc/sec. band become so at 28 mc/sec and higher. These three factors alone are sufficient to put out of court all ideas of band-switching if the best possible performance is required. Image response becomes a major difficulty rather than a minor one, and set noise becomes relatively more important still on account of the lack of QRN on the higher frequencies. It is at this stage that greater complexity, in the shape of double superheterodyne reception, becomes necessary if characteristics comparable to those achieved on lower frequencies are to be realised. Above 28 mc/sec., too, comes the question of the advisability of using special ultra-high frequency tubes, such as the acorn or the new 6.3v. miniatures. The design of the actual stage circuits also becomes more difficult. All these factors point to the use of special receivers for the bands higher in frequency than the 10-metre band.

The great advantages of the double superhet. instantly bring to mind the use of converters. These allow the signal frequency circuits to be specially designed, with resultant increase in gain, selectivity, and signal-to-noise ratio, and permit the use of a very high first I.F. if a good main receiver is available. This, in turn, enables excellent image rejection to be obtained, while the low second I.F. on, say, 465 kc/sec. gives all the adjacent channel selectivity that can be used.

On higher frequencies than the 10 and 6-metre bands, the use of a double superhet. may become unprofitable once more, because of the use of self-excited transmitters whose frequency stability is not great enough to allow high adjacent channel selectivity to be used. These conditions call for either super-regenerative receivers, or for straight superhets. with an I.F. of 10 mc/sec. or higher, so that the overall selectivity will not be too great.

From the above, it can be seen that the whole question of receiver design is one of great complexity, when viewed in all its aspects. Many points of some importance have not been mentioned at all, since space does not permit, but it is hoped that this article may have given some clues to those who are endeavouring to decide what type of receiver to build for a given purpose, and at the same time some ideas which, if developed, may produce better and better amateur receivers.

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Accessories include 34 ft. aerial mast in sections; dynamic and carbon mikes; dynamic headphones; remote control units and cable drums; spare valves, etc.

The sets are ideally suited for licensed amateurs as the frequency range includes the 80- and 40-meter bands. Well suited for marine and mobile installation and for technical schools and colleges requiring high-grade equipment.

All the equipment illustrated is contained in the original overseas pack consisting of two cases and one aerial pack. Batteries are NOT included.

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This is an opportunity to purchase a very efficient communications unit at a small fraction of the original cost.

WARNING: It is an offence against the Post and Telegraph Act to establish a radio transmitting station unless the station is licensed by the postal authorities.

TUBE DATA

In this series we are publishing curves and operating data of tubes which are of considerable use to the amateur designer, and whose characteristics are not so readily available as those of other types. We feel sure that the series will fill a long-standing need, not only of designers, but also of servicemen and other workers.

TYPE ECH-35 TRIODE HEXODE

General.

Type ECH-35 is a frequency changer valve comprising a triode oscillator and hexode modulator on a common cathode—the triode being mounted vertically below the hexode part.

The signal is applied to the innermost grid of the hexode which has variable mu properties. The oscillator grid is internally connected to the third (injector) grid of the hexode, which is isolated from signal grid and anode by the second and fourth grids which are connected together and comprise the screen.

Short Wave Operation.

Type ECH-35 is particularly well suited for short wave operation because of its high conversion conductance of 650 μa/v at full gain and remarkably low frequency drift; the latter remaining low when the valve is under A.V.C. control. Mains voltage fluctuations have also a small effect only and when the oscillator tuned circuit is connected in the triode anode lead a mains fluctuation of 10 per cent. will produce a frequency drift of less than 1 K.C. at 20 mc/s The change in oscillator frequency on biasing the hexode to cut-off is less than 3 K.C.'s at 20 mc/s with a tuned circuit capacity of 50 $\mu\mu f$.

Conversion Slope.

The high conversion slope results from the high slope of the hexode from grid 1 to anode and the sharp fall of this slope with increasing negative voltage on grid 3. Another result is that only a low oscillator A.C. voltage is required, amounting to 8v. R.M.S. for optimum performance. The conversion slope remains high over a wide range of oscillator voltage; at 5v. it is approximately 580 μa/v and falls but slightly from the maximum value at double the optimum voltage. This wide tolerance simplifies the design for wide wave ranges since a considerable change of oscillator output has little effect on the conversion slope and amplification. (See Fig. 3.)

The optimum value of 8v. R.M.S. (200 μa in a grid leak of 50,000 ohms), represents the most favourable compromise between noise, heterodyne whistles and conversion gain.

Lower Oscillator Frequency.

In the hexode there is no electron coupling between the signal grid and the third grid, but

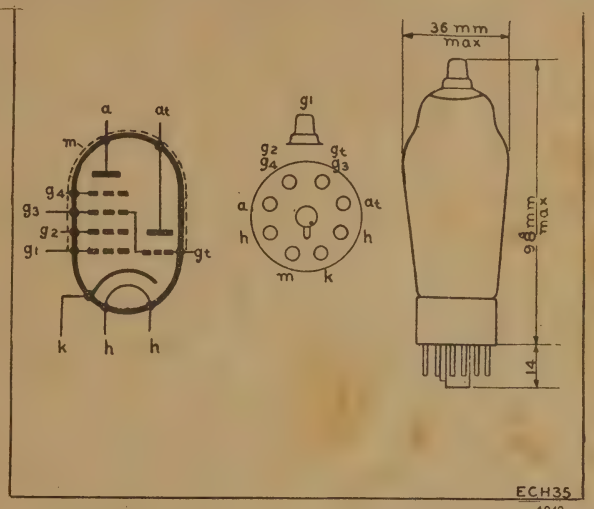

Fig. 1. Socket connections and valve dimensions.

there is, of course, a small capacity between them. The effect of this is that at about 25 mc/s an A.C. voltage of oscillator frequency and having an amplitude approximating 0.5v. will appear at the signal grid. This, however, has but a small effect on the conversion slope, and need not be detrimental.

The A.C. voltage at oscillator frequency appearing at the signal grid through the capacity to the third grid increases or reduces the conversion slope, according to whether the oscillator frequency is higher or lower than the signal frequency. It is better to operate the oscillator higher in frequency than the signal.

Triode Characteristics.

The triode section anode current versus grid volts curves are shown for anode voltages of 150 and 100 in Fig. 5.

ELECTRICAL DATA.

1. **HEATER**—Indirect heating, A.C. or D.C.

Heater voltage	6.3v.
Heater current	0.3 amp.

2.—**CAPACITIES:**

(a) Hexode.		(b) Triode.	
Input Cap. (g_1 — cath.)	5.0 $\mu\mu f$.	C (g — cath.)	9.0 $\mu\mu f$.
Output Cap. (p — cath.)	10.0 $\mu\mu f$.	C (p — cath.)	5.0 $\mu\mu f$.
C (p — g_1)	0.003 $\mu\mu f$.	C (p — g)	1.6 $\mu\mu f$.

(c) Between Hexode and Triode.

C (triode grid — hexode g_1) ..... 0.3 $\mu\mu f$.

3. **OPERATING CHARACTERISTICS OF HEXODE AS MIXER:**

(a) Fixed Screen Voltage.

Plate Voltage	200v.	250v.
Screen Voltage	100v.	100v.
Cathode Bias Resis.	215 ohms	215 ohms
Osc. Grid Leak	50k.	50k.
Osc. Grid Current	200 μ a.	200 μa.
Min. Grid Bias	— 2v.	— 2v.
Plate Current	3 ma.	3 ma.
Screen Current	3 ma.	3 ma.
Conversion Conductance	650 μa/v.	650μa/v.
Plate Resistance	0.9 meg.	1.3 meg.

(b) Screen Supply Through Potentiometer.

Plate Voltage		250v.	
Potentiometer Res. R_1 (Figs. 2 and 4)		24k.	
Potentiometer Res. R_2 (Figs 2 and 4)		33k.	
Cathode Bias Res.		215 ohms	
Osc. Grid Leak		50k.	
Osc. Grid Current		200 μ a	
Grid Bias	— 2v. (min.)	— 23.5v.	— 31v.
Screen Voltage	100v.	—	145v.
Plate Current	3 ma.	—	—
Screen Current	3 ma.	—	—
Conversion Conductance	650μa/v.	6.5μa/v.	1.5μa/v.
Plate Resistance	1.3 meg.	3 meg.	4 meg.

(c) Condition for Best Sig./Noise Ratio.

Plate Voltage		250v.	
Potentiometer Res. R_1		47k.	
Potentiometer Res. R_2		33k.	
Cathode Bias Res.		310 ohms	
Osc. Grid Leak		50k.	
Osc. Grid Current		200 μ a	
Grid Bias	— 2v.	— 19v.	— 23v.
Screen Voltage	70v.	—	100v.
Plate Current	1.5 ma.	—	—
Screen Current	1.6 ma.	—	—
Conversion Conductance	450μa/v.	4.5 μa/v.	1.5μa/v.
Plate Resistance	2 meg.	5 meg.	6 meg.

4. **TRIODE CHARACTERISTICS AS OSCILLATOR**

Plate Voltage	100v.	150v.	—
Supply Voltage (Through Resistance)	—	—	250v.
Plate Supply Resistance	—	—	45k.
Plate Current (Oscillating)	3.3 ma.	8 ma.	3.3 ma.
Mutual Conductance	2.8 ma./v.	3.8 ma./v.	2.8 ma./v.
Amplification Factor	24	24	24

Due to the high slope of the triode the starting and maintenance of oscillations will not present any difficulties and the feed-back coil may be rather loosely coupled.

The recommended value of grid leak is 50,000 ohms and the grid condenser 50$\mu\mu f$. These values are suitable for all wave ranges. To keep frequency drift to a minimum and to facilitate tracking of the oscillator, it is recommended to insert the tuned circuit in the anode side of the feed-back coil in the grid circuit of the triode.

In Fig. 2 is shown a typical circuit for ECH-35. For parallel feed of the oscillator as shown, the feed resistor with an anode supply of 250v. should be 30,000 to 45,000 ohms and the blocking condenser 100 $\mu\mu f$. On the broadcast band it may be advantageous to return the feedback coil to the padding condenser, to keep the oscillator more nearly constant. On short-wave the oscillator

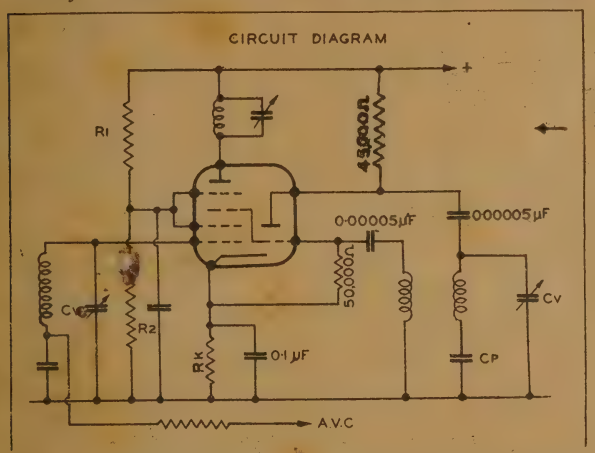

Fig. 2. Type ECH-35 valve. Typical circuit diagram.

voltage may be held constant by inserting a resistor of about 100 ohms in series with the feedback coil. This resistor operates with the triode input capacity to produce a damping which increases rapidly with frequency.

Screen Voltage Supply and A.V.C.

As the mixing section of the valve is a hexode, without a suppressor grid, it is preferable for the screen voltage to be obtained from a voltage dividing network rather than from a series voltage dropping resistor. The variation of screen current with control grid voltage is shown in the graph of Fig. 4. When the conversion slope of the valve is greatly reduced by the biasing voltage applied to the control grid, as may result from the action of the A.V.C. circuits on strong signals, the current through the screen is greatly reduced, and, if supplied through a series voltage dropping resistance, the screen voltage may rise until it approaches that of the anode, under which condition secondary emission may take place from the anode causing a drop in the anode cathode internal resistance which would reduce the selectivity of the tuned circuits fed from the anode.

Fig. 4 shows, by means of two load lines, the variation in screen voltage with control grid volts when the screen is fed through the voltage dividing network R_1, R_2 shown in Fig. 2 having the values indicated in Fig. 4.

The variation of conversion slope with control grid voltage (A.V.C.) can be controlled by varying the size of the resistors R_1 and R_2 in the voltage dividing network. Fig. 7 shows the dependence of hexode anode current as a function of the control grid voltage for different values of screen grid voltage (plate voltage 200-250 volts).

Conversion Slope & Oscillator Grid Current.

Fig. 3 depicts the dependence of conversion slope, and anode internal resistance, on the oscillator grid current through a grid leak of 50,000 ohms, with fixed screen voltage. A fairly flat peak is obtained with a grid current of 200 μa. The conversion slope falls slightly for higher values.

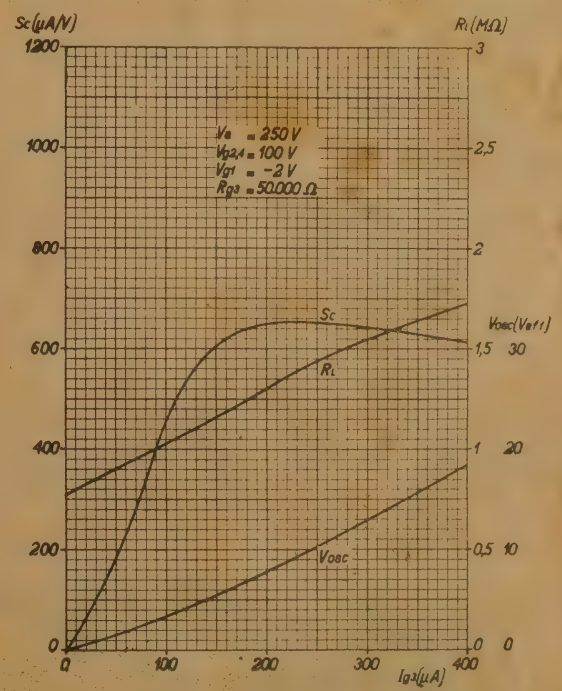

Fig. 3.

Cross Modulation and Hum Modulation.

In any valve with a curved characteristic—that is, in any valve suitable for control of

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- **UNIT TYPE S**

  Incorporating an R.N.Z. 8 in. P.M. speaker in walnut veneer case with volume control. Designed for general paging and low level indoor sound distribution. Power handling capacity 4 watts. Dimensions: Front, 12 in. x 12 in.; depth, front to rear, 7½ in.

- **UNIT TYPE SFS 8**

  Incorporating an R.N.Z. 8 in. P.M. speaker in metal case with single directional flare. Designed for general paging and low level sound distribution. Power handling capacity 5 watts. Dimensions: Flare, 13 in. x 13 in.; front to rear, 13 in.

- **UNIT TYPE SFS 10**

  Similar to Type SFS8 but with R.N.Z. 10 in. P.M. speaker. Power handling capacity 7 watts. Dimensions: Flare, 13 in. x 13 in.; front to rear, 15 in.

- **UNIT TYPE DFS 8**

  Similar to Type SFS8 except that double flares are provided for bi-directional sound distribution in opposite directions. Dimensions: Flares, 13 in. x 13 in.; length overall, 21 in.

- **UNIT TYPE DFS 10**

  Equivalent to Type DFS8 but incorporating 10 in. speaker. Power handling capacity 7 watts. Dimensions: Flares, 13 in. x 13 in.; length overall, 24 in.

- **UNIT TYPE NU 8**

  Searchlight type with spun aluminium casing and flare incorporating R.N.Z. 8 in. P.M. speaker. Pedestal mounted and adjustable for directional distribution of sound. Weather-proofed for outdoor use. Power handling capacity 6.5 watts. Dimensions: Flare diameter, 14 in.; overall height from base of pedestal, 15 in.; depth, front to rear, 12 in.

- **UNIT TYPE G**

  High-pressure exponential horn speaker incorporating a Grampian pressure unit in a cast aluminium throat with spun aluminium flare. Designed and weather-proofed for outdoor sound projection. With an exponential cut-off characteristic at about 300 c.p.s. the unit is particularly suitable for speech projection. Power handling capacity 10 watts. Dimensions: Flare diameter, 21 in.; length overall, 38½ in.

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EQUIPMENT

• UNIT TYPE PR 10

Incorporating an R.N.Z. 10 in. P.M. speaker in a large exponential flared metal casing. Designed for general outdoor use (speech and music) with moderately directional distribution. Power handling capacity 10 watts. Dimensions: Flare, 27 in. x 27 in.; depth, front to rear, 24 in.

• UNIT TYPE PR 12

Similar to Type PR10 but incorporating a 12 in. Goodman P.M. speaker. Power handling capacity 15 watts. Dimensions: Flare, 27 in. x 27 in.; depth, front to rear, 26 in.

• UNIT TYPE HR

Infinite baffle type in walnut veneer case with volume control and incorporating R.N.Z. 10 in. P.M. speaker. Designed for general paging and indoor sound distribution. Power handling capacity 6.5 watts. Dimensions: Front, 15½ in. x 18 in.; depth, front to rear, 7¼ in.

• UNIT TYPE HRL 10

Similar to Type HR but with larger infinite baffle. Designed for high quality indoor sound distribution and musical appreciation work. Power handling capacity 10 watts. Dimensions: Front, 23 in. x 25½ in.; depth, front to rear, 11¾ in.

• UNIT TYPE HRL 12

As Type HR10 but incorporating a Goodman 12 in. P.M. speaker. Power handling capacity 15 watts.

• UNIT TYPE BR 10

Bass reflex baffle in a handsome "console" style cabinet incorporating R.N.Z. 10 in. P.M. speaker. Designed for high-quality studio or auditorium use. Power handling capacity 10 watts. Dimensions: Height, 36 in.; width, 25 in.; depth, 15 in.

• UNIT TYPE BR 12

Similar to Type BR10 but incorporating Goodman 12 in. P.M. speaker. Power handling capacity 15 watts.

Further details and price list available upon application

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transconductance by the grid bias potential—the curvature may cause harmonic distortion.

If two modulated carriers are applied to the control grid of such a valve (this happens when close to a local transmitter) cross modulation occurs between the two carriers, and interference is caused by the cross-modulating station.

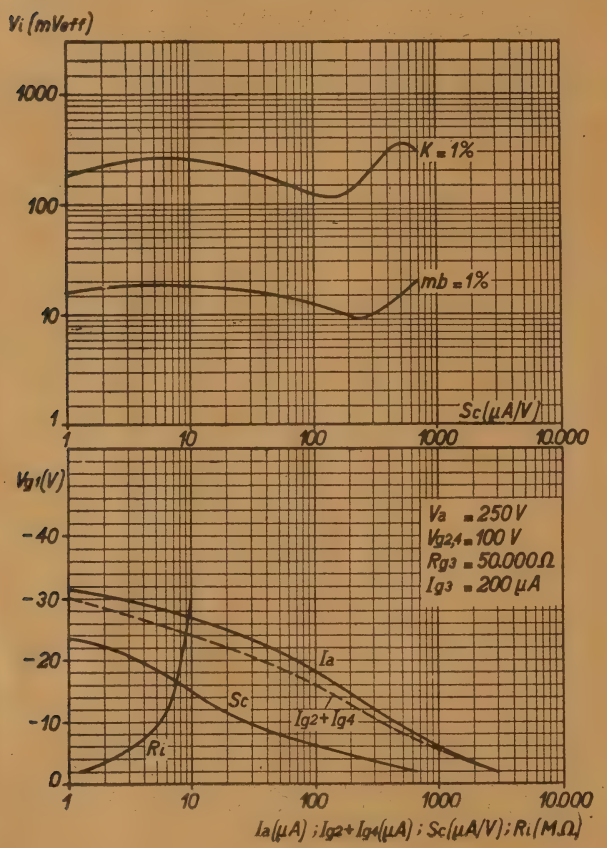

Fig. 6.

The maximum permissible interfering signal voltage which may be applied to the control grid for cross modulation of K = 1 per cent. with different values of conversion slope is shown in the upper portion of Fig. 6. In Fig. 6 the screen voltage is fixed at 100.

Similarly, the figure shows the maximum low frequency voltage which may be derived from the supply mains and applied to the control grid, together with a wanted signal, for the signal to be modulated by mb = 1 per cent.

Incidentally, conditions which produce 1 per cent. cross modulation would produce 0.83 per cent. third harmonic distortion of a modulated signal, while those conditions which would cause

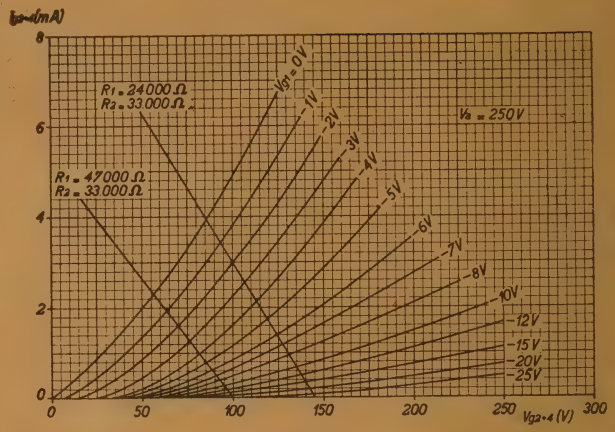

Fig. 4.
Screen current, Vs; screen voltage, Vg_1, as parameter.

1 per cent. hum modulation would cause 0.25 per cent. second harmonic distortion; so this Fig. 6 is also a guide as to the level of the input signal which can be handled with reasonable distortion.

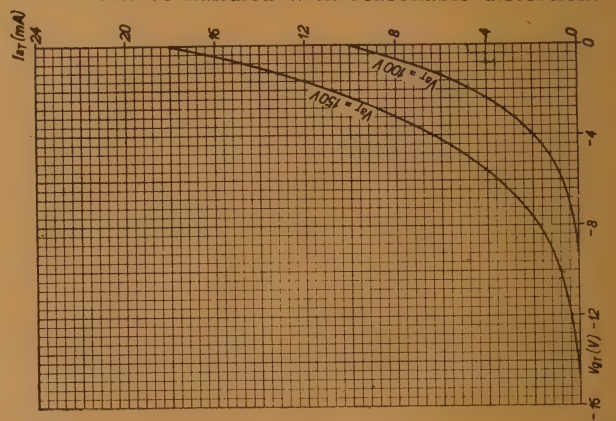

Fig. 5. Mutual characteristic of triode section.

Anode Current, Screen Current, Conversion Slope and Anode Resistance Variation with Control Grid Voltage.

The lower portion of Fig. 6 shows variations in the anode current, screen current, conversion slope and anode resistance with respect to control grid voltage for the conditions specified on the figure.

It will be noted that some of the symbols on these diagrams differ from those normally in use by most manufacturers. The most notable difference is that Sc standing for "conversion slope" is used instead of the more usual gc for "conversion conductance," these two terms being interchangeable. Ia is used instead of Ip for plate current, and Ri (internal resistance) is used

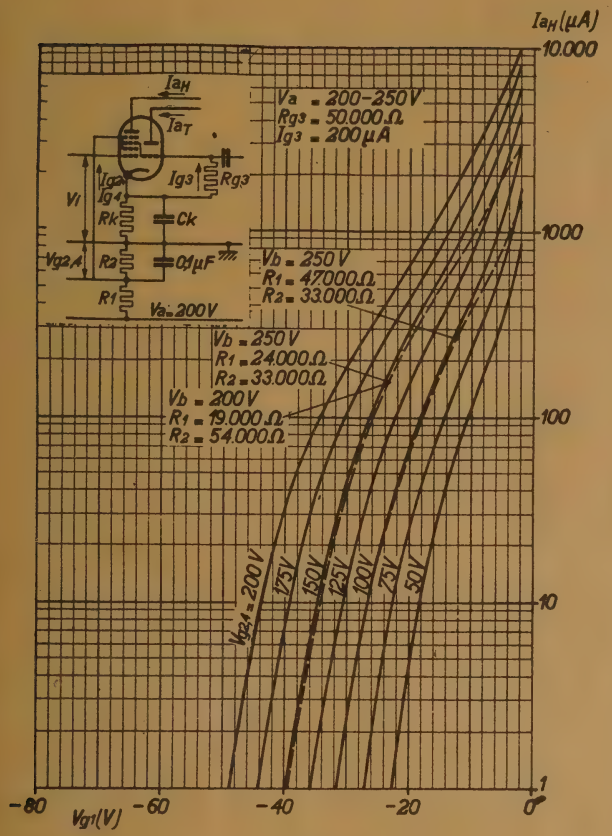

Fig. 7.
Plate current Vs grid voltage.

instead of Rp (plate resistance). With these differences in mind, there should be no difficulty in interpreting the diagrams.

FOR THE SERVICEMAN

We know that many radio service shops are justly proud of the efficient and workman-like lay-out of their test benches, and that interchange of ideas can be beneficial to all concerned. We therefore invite those who have good photographs of their service department to submit them to us so that we may use them for publication in our service page. We also suggest that the photographs be accompanied by a short technical description of the test equipment with particular reference to any new ideas.

THE EDITORS.

'RADIO and ELECTRONICS'

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RADIO-FREQUENCY HEATING—Part 2

By Dr. L. HARTSHORN, National Physical Laboratory.

DIELECTRIC HEATING.

In the induction heating of metals the power is transferred to the metal by the magnetic field which penetrates the outer layers of the metal, and there induces eddy-currents or the circulation of free electrons which dissipate the whole of the power before it has penetrated to any considerable depth; the material can be said to be very OPAQUE to the flux of energy. The same action must occur to some extent in a dielectric, but it is usually too small to be detected, because these materials do not contain enough free electrons or ions to carry appreciable eddy-currents. In other words, the dielectric is TRANSPARENT to the flux of energy, the magnetic field penetrating it completely.

The most characteristic property of a dielectric and the one which distinguishes it from a conductor is that when it is placed in an electric field a definite potential gradient or electrical stress is established within it, which stress produces an electric strain or displacement, the material thereby acquiring energy that is distributed throughout its volume. The energy of a charged condenser is a very familiar instance, and we know that every element of volume of the dielectric of such a condenser must be credited with stored energy of a concentration that is proportional to the product of its dielectric constant x and the square of the field-strength F. It is in this way that the energy is transferred to the material in dielectric heating. We must now consider how it is absorbed, but before doing so we may note that no such transfer occurs to a metal because the field does not penetrate the metal.

The extent to which the energy transferred is absorbed when the field is periodic will depend entirely on the character of the forces controlling the displacement. A displacement of an elastic type, being always in phase with the driving force, gives rise to no net loss or absorption of energy in any number of complete cycles, but a displacement that is retarded by any force of a frictional or viscous character will lag in phase with respect to the driving force, the electric field, and will give rise to a definite loss or absorption of enery in each cycle. It is found in radio practice that for solids and liquids there always is an observable phase difference, δ, between the electric force and displacement, and that within wide limits δ is characteristic of the material and independent of its size and the field-strength F. This can only mean that in every cycle a definite fraction of the total energy put into any element of volume of the material by the field is absorbed, and this fraction turns out to be proportional to tan δ, which is therefore called, somewhat loosely, the "power-factor" of the material. It follows that the concentration of absorbed power in any element of volume of a dielectric is proportional to $xf.\tan\delta.F$, where f denotes frequency.

This simple relation has several important consequences. First, other things being equal, the concentration of absorbed power, and therefore the heating, is proportional to the frequency and to the power factor of the material. For this reason dielectric heating is usually carried out at as high a frequency as is practicable, and materials of high power factor are selected for treatment if possible. Secondly, if the material is homogeneous and the field can be made uniform, the heat is uniformly distributed throughout the whole of the material. Thirdly, when the field is not uniform, there is a strong concentration of heat in the part of the material occupying the strongest part of the field. Fourthly, when a composite material is treated, the rates of heating the several components are controlled by their dielectric properties, x and $\tan\delta$. The great importance of these features of the process will be illustrated by a few typical examples.

UNIFORM HEATING IN DEPTH.

Probably the most important characteristic of dielectric heating is that, when a homogeneous material is placed in a uniform field, the heat is distributed uniformly throughout its volume, however thick the material may be. By this process we can, therefore, heat uniformly very thick layers of a material that may be a very poor conductor of heat, an operation that cannot be performed by any other method. Dielectric heating is indeed our only process for the heating of poorly-conducting solids in depth.

The following examples illustrate the value of this feature of the process. The first is the moulding of plastics. Heat must be supplied to the moulding material in order to bring it into the plastic condition in which it can flow under pressure into every part of the mould. The heat is commonly supplied by contact with the mould itself, which is heated for the purpose, but the rate at which the heat penetrates the material is restricted by its low thermal conductivity, and this sets a limit to the speed of the whole operation and the thickness of the mouldings that can be satisfactorily made. These limitations are overcome by the dielectric heating of the material immediately before the actual moulding operation. The moulding material, usually supplied in the form of cold-pressed pellets, is placed between the condenser plates of a radio-generator, and in a matter of seconds its temperature throughout rises to the point at which it will flow evenly under pressure. It is then transferred to the press and the moulding operation completed.

Plywood manufacture affords another example. The synthetic resin glues, now largely used, set in, say, eight hours when cold, but can be made to set in a few minutes by heating to 60 to 80 degrees Centigrade. Thus the bonding of thin veneers with these glues to form plywood can be greatly accelerated by the application of heat. Considerable pressure is required for the production of good glued joints, and if this is applied by means of a press with heated platens, small thicknesses of wood can be heated by conduction from the platens, but with large thicknesses the operation becomes slow and uneven. By means of dielectric-heating, stacks of plywood up to 2ft. thick can be heated uniformly and bonded in one operation. A thin metal plate in the centre of the stack forms

one electrode, and the two platens of the press, which are necessarily connected together by its framework, form the other. A few hundred kilowatts of radio-power is applied to the condenser so formed, and the temperature throughout the mass of 50 cubic feet or so of laminated wood rises to the point at which the whole bonding operation is completed in a matter of minutes instead of hours.

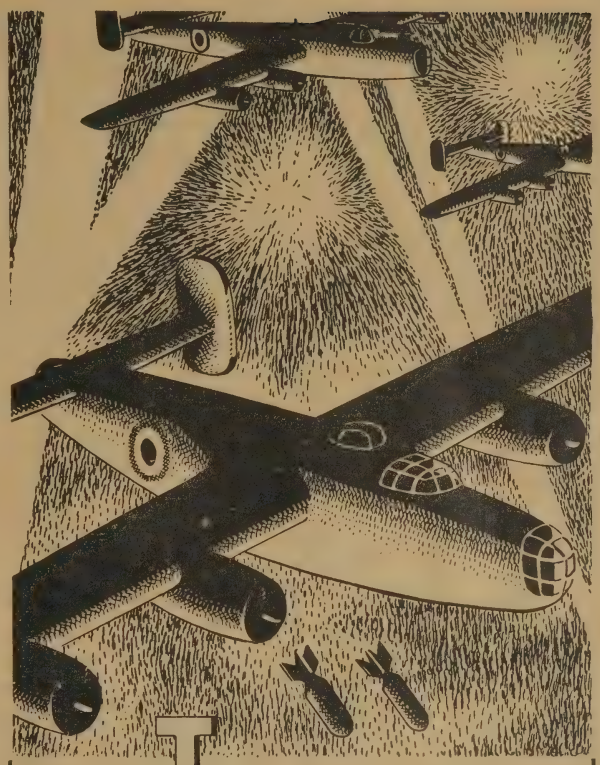
The application of the method to the rapid production of curved objects in wood will be, I think, sufficiently obvious. The veneers are thin enough to bend very readily, and it is only necessary to bond them together while they are pressed in a jig between rigid surfaces of wood or metal having the required contour.

The process is also of great value in certain drying operations. The drying of poorly-conducting materials in large masses in ovens and kilns is always a very tedious business, because the conduction of heat into the centre of the material and the diffusion of water out of it are both very slow processes. When dielectric-heating is used, the centre of the material is heated instantly and soon becomes hotter than the outer layers which are cooled by evaporation and air convection. The relatively high internal temperature produces a correspondingly high internal vapour-pressure, which under favourable conditions drives out the water with great speed. I should perhaps mention that the process must be applied with caution to any material that is liable to be damaged by heating to a temperature of 100 degrees Centigrade or less.

SPOT GLUING AND WELDING.

Another important quality is the ease and precision with which dielectric-heating can be localised. It has been seen that the heat generated is proportional to the square of the electric field strength. If, therefore, we wish to heat one particular spot of a material only, we merely have to place two small electrodes one on either side of the spot, and deliver the appropriate amount of power to them. The field being almost entirely concentrated in the narrow gap between the electrodes, the heat appears there only. This localised heating provides us with several operations for the jointing of non-metals, analagous to the soldering, brazing, and welding of metals.

The process is used in assembling the complex wood structures that go to build up, say, the Mosquito aeroplane. Many such structures consist of thin skins of plywood moulded to the desired streamline contour, and supported and made rigid by girders or bulkheads, also of wood. The veneers from which the plywood is built up and also the supporting members are bonded with synthetic resin glues by means similar to those already considered, which involve the application of considerable pressure while the glues are hardening; only in this way can the full strength of the joint, which, I may say, exceeds that of the wood itself, be obtained. But some means must be provided for tacking the various pieces into their proper positions while the structure is being built up into a form to which the necessary pressure can be applied. Metal screws, pins, and staples are often used for the purpose, but they are undesirable since they necessarily weaken the wood at the point at which they pierce it. Spot gluing by localised radio-heating solves this problem. The equipment consists of a small radio-generator which de-



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livers, say, 100 watts of power at 100-200 mc/sec. through a flexible cable to a pair of small electrodes mounted on a handle shaped like a short gun. The tip of the gun barrel forms one electrode, while the other is a central stud, which when not in use projects a little beyond the end of the barrel, but can be pushed back against a spring. The gun is pressed on the spot to be glued; the inner stud is thus pushed back into the barrel until both electrodes make contact with the surface of the wood. The movement of the stud operates a switch and timing device, which switch on the radio-power to the electrodes for the few seconds required to harden the glue-film at the spot covered by the gun. The electric field is, of course, highly concentrated around the surface of the small inner electrode, and it is here that the heat is localised. The timing device is adjusted to suit the work in hand. The operation is very simple and rapid.

Thermoplastic material in sheet form can be welded by a somewhat similar technique; both spot welding and seam welding are practised. In seam welding the overlapping sheets are drawn between two small roller electrodes, and the power and speed are adjusted until the power is just sufficient to soften the material in the short time it remains between the two rollers. The pressure of the rollers makes the two soft materials flow together and ensures a good weld, and the joint is cooled by the surrounding air as soon as it emerges from between the rollers. The device can be made to be operated like a sewing machine. Spot welding is performed by means of another gun in which the central electrode has the form of a small roller which is pressed on to the overlapping sheets. Again intense local heating occurs in the strong field immediately surrounding the small electrode, and a good spot weld is made in a second or less.

SELECTIVE HEATING.

One of the most interesting features of dielectric heating still remains to be considered; we can sometimes arrange to supply heat to a mixture of two substances in such a way that nearly all the heat appears in one of them only. We have seen that the concentration of the heat generated within any material is proportional to the product of its power factor, dielectric constant, and the square of the field-strength or voltage gradient. Now, although the field between the electrodes may be uniform before the body is inserted, it is not necessarily so afterwards; the relative field strength in the two constituents of a mixture depends on their dielectric constants. However, the variation of this property from one material to another is usually trifling in comparison with the differences of power factor; and in practice, therefore, the concentration of heat in the two constituents of a mixture is roughly proportional to their power factor, and any part of a composite body having a very low power factor remains quite cool in a field which generates considerable heat in parts of high power factor.

A single example will be sufficient to show the value of this property. Take, for example, its bearing on the sterilisation of foodstuffs and biological materials generally. If we can find a frequency at which the power factor of the pests we want to get rid of is high, and that of the material to be sterilised is low, we shall have an ideal sterilising process. An appropriate electric field applied for a very short time would heat the pest enough to kill it without causing any unnecessary and possibly harmful heating of the good material. A very early suggested use for the process was the killing of pests in plant bulbs, and experiments have also been made on grain and other materials. The process is undoubtedly effective in killing the pests; but the extent to which selective heating has occurred is doubtful.

I have here selected those features of radio-heating that are of scientific interest. The industrial value of the process is largely bound up with economic considerations that I have barely mentioned. Radio power is at least ten times as expensive as heat in its cheaper forms, and its industrial use for heating purposes is therefore only justified when it results in a considerable saving of labour, time, or floor-space or some such item as is far more costly than mere power in bulk. Nevertheless, it has had some remarkable industrial successes, and no one can doubt that it will have an important place in the industry of the future. It is, however, as a new scientific tool that I have preferred to consider it; a tool that enables us to manipulate thermal energy with precision in circumstances where others fail, and which therefore in some measure extends the range of experimental inquiry.

'Radio and Electronics'

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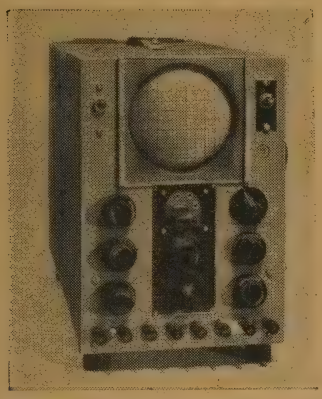

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This page is contributed monthly by the New Zealand DX Radio Association (Inc.), 20 Marion Street, C.2, Wellington, New Zealand. All "DX" and Club inquiries should be addressed direct to the Association.

THIS "DX-ING"

STATIONS TO BE HEARD

JCKW, 7220kcs.—Jerusalem, Palestine; English news at 5 a.m.

CSW6, 11040kcs.—Lisbon, Portugal; good listening, 7-8 a.m.

FXE, 8020kcs.—Beruit, Syria; heard around 3-4 a.m.

FO8AA, 6980kcs.—Papeete, Tahiti, 4.30 p.m.

COKG, 8960kcs.—Santiago, Cuba, 3.30 p.m.

SUX, 7860kcs.—Cairo, 7-8 a.m.

ZAA, 7850kcs.—Tirana, Albania, 7-8 a.m.

OLR4A, 11840kcs.—Prague, Czechoslovakia; English news, 7.30 a.m.

SEAC, 15300kcs.—Singapore; opens at 8.45 a.m. carrying same programme as 15275kcs.

XORA, 11680kcs.—Shanghai, China; English programme at 9.30 p.m.

———, **9350kcs.**—Radio Sofia, Bulgaria; English news at 8.30 a.m. requesting reports to be addressed to Radio Sofia, Anglo-American Service, Sofia, Bulgaria.

———, **11780kcs.**—Radio Saigon, French Indo-China; good at 10 p.m.

———, **7295kcs.**—Radio Athens, Greece; English news at 8.15 a.m.

ARMED FORCES RADIO SERVICE

Eighth United States Army, Japan

The following is an official list of Armed Forces Radio Stations operating in Japan:—

Station	Location	Frequency (kcs.)	Power (watts)
WVTQ	Osaka	1310	10,000
WVTQ Relay	Ngayoa	1340	10,000
WVTQ Relay	Tsuruga	1180	500
WLKH	Kokura	1520	500
WLKA	Kagoshima	1490	400
WVTO	Omura	1450	400
WLKB	Nigata	1430	400
WLKD	Sapporo	1420	7,000
WLKF	Kumamoto	1400	3,000
WLKE	Sendai	1370	3,000
WLKI	Fukuoka	1360	50
WLKI Relay	Kure	930	10
WVTR	Tokyo	590	50,000
WVTR Short-wave	Tokyo	6075	10,000
WVTR Short-wave	Tokyo	3015	10,000

The low-power transmitters in most cases are mobile Army units that have been reconverted. The high-power transmitters are Japanese. It is believed all small stations on Kyushu are going to merge and use a 10kw. American-made transmitter. This station hopes to broadcast short-wave in the near future. Our thanks to Niall Tabor, Chief Engineer.

STATION ADDRESSES

ARGENTINE:

LRX.—Calle Maipu 555, Buenos Aires.

LRA-1.—"Radio del Estado," Dirrecion General de y Telegrafos, Buenos Aires.

LRS-LRS-1.—Radio Splendid, Calle Ayacucho 1556, Buenos Aires.

LSX.—Transradio Internacional, San Martin 329, Buenos Aires.

ANGOLA:

CR6RB.—Radio Club de Benguela, Caixa Postal 19, Benguela.

CR6AA.—Estacio Radio Difusora, Caixa Postal 103, Lobito.

ANDORRA:

————"Radio Andorra," Eoch'd Ells, Escls.

AZORES:

ERA.—Emissor National de Radiofusao, Emissor Reginol dos Azores, Ponta Delgada.

AUSTRALIA:

VLA, VLC, VLH, VLG, VLR.—"Radio Australia," Department of Information, Melbourne, Victoria, Australia. (P.O. Box 780H.)

VLW.—Postmaster-General's Department, National Broadcasting Service, Perth, Western Australia.

BAHAMAS:

ZNS-2.—C/o Broadcasting Station ZNS, Telecommunications Department, Bahamas Government, Nassau.

BELGIAN CONGO:

OTC.—"Radio National Belge," Office de Radiodiffusion Nationale Belge, Leopoldville.

BRITISH SOMALILAND:

————"Radio Somali," Information Broadcasting Department, Hargeisa.

BRAZIL:

PRF-6.—"Radio Bare," Caixa Postal 296, Manaus, Amazonas.

PRC-5.—"Radio Clube Do Para," Edif Bern Av 15 de Agosto, Belem, Para.

PSH.—P.O. Box 709, Rio de Janeiro.

PRE-9.—"Ceara Radio Club," Caiza Postal 222, Fortaleza.

ZYB-7.—"Radio Difusora Sao Paolo," Sao Paolo.

PRF-5.—National Department of Propaganda, Rio de Janiero.

BRITISH GUIANA:

ZFY.—The British Guiana Broadcasting Co., Ltd., P.O. Box 272, Georgetown.

BOLIVIA:

CP-2, CP-38.—Casilla Corres 596, La Paz.

CP-5.—"Radio Illumani," Casilla 637, La Paz.

CP-43.—"Radio Tupiza," Casilla 13, Tupiza.

THE NEW ZEALAND ELECTRONICS INSTITUTE

The efforts of the various committees concerned with the promotion of the New Zealand Electronics Institute were rewarded with the formation of the Institute in Wellington on July 10, 1946.

The members of the committees have been actuated by two objectives, the attainment of which will overcome two serious deficiencies in the field of radio and electronics in New Zealand. The first of these is the absence of any organisation which is representative of industry, the services and the teaching profession in connection with the theoretical and the practical aspects of radio and electronics. The second deficiency is the lack of any professional status for attainment by those possessing specialised knowledge and training in this field beyond the requirements of the various Government Department's examinations.

The fields of science and industry encompassed by radio and electronics have expanded very rapidly in recent years with the result that greater progress has been made in these fields than in any other human endeavour, and electronic technique is now finding an increasing number of applications in branches of science and industry which were foreign to it a decade ago. On the other hand there is a conspicuous time-lag both in education in electronics and in the professional status of the electronics engineer, more so perhaps in New Zealand than in any other country.

The objective of the N.Z. Electronics Institute is a long-term one. Its attainment is contingent upon the advancement of regularised education in electronics upon obtaining a professional status for men engaged in the applications of electronics and upon the setting of standards in keeping with the technical knowledge and special skill which these men possess. In its inception the Institute is endeavouring to begin on a sufficiently ambitious basis without setting up an elaborate organisation. The graded membership has required more time in its consideration than any other aspect of the constitution. For the Institute in its early stages to seek to organise a membership along the lines of a learned institution, the membership would require to consist of men having professional qualifications in engineering who are earning their livelihood in the application of electronics. The number of these in New Zealand is comparatively small because formerly electronics was regarded mainly as a science rather than a branch of engineering and universities included electronics in the science course in preference to the engineering course. Today, with the increasingly better facilities available for instruction, electronic engineering is being taught at Schools of Engineering associated with the University of New Zealand and it is within the realms of possibility that Applied Electronics will be part of the course in Electrical Engineering in the near future.

The constitution of the Institute is a compromise between practicability and idealism and provides a solid foundation upon which to build. The title has been changed from that of the original proposal to "The New Zealand Electronics Institute," using the term "Electronics" rather than the restricted term "Radio." The corporate members consist of those having membership in the two highest grades and the rules provide for associates and students. Special encouragement is to be given to the students to seek by training and examination, to qualify for membership in a higher grade. The associate grade is one for those who possess a recognised combination qualification coupled with practical experience although provision is made for entrance to this grade, under certain conditions, without examination qualification. Entrance to the higher grades is more difficult, and it is from these grades that the officers are elected. Special attention has been given to the qualifications to ensure that high academic qualifications alone are not sufficient for admission to these grades without considerable practical experience.

The aims and objects of the Institute are to encourage the development of electronic knowledge among the members with a view to the ultimate benefit to society as a whole from the applications of this knowledge. For the fulfilment of the objects, the configuration of the Dominion does not make practicable the centralising of meetings in one town, and, in order to provide greater opportunities for assistance to members, the constitution provides for the formation of branches. These are not bodies with separate entity but are general meetings of the Institute held in any town where there are sufficient resident members and convened in the interests of all members who may be able to attend for the purpose of promoting the objects of the Institute. Since the formation, seven meetings have been held among the branches and it is intended whenever possible for papers read and copies of addresses given to be circulated among the members.

The general management is placed in the hands of the council, which is elected at the annual meeting. The council is representative of the whole Dominion, and the main branches must have direct representation on the council.

The important task of admitting members is placed in the hands of an Admissions Committee which is appointed by the council. Admissions are made in accordance with the rules and upon the evidence of qualifications submitted.

All applications and correspondence should be addressed to the Secretary, N.Z. Electronics Institute, G.P.O. Box 219, Wellington.

THE CANTERBURY PROJECT

In our June issue we published a complete description of the large-scale scientific investigation, known as the Canterbury Project, which is to be carried out in New Zealand. The world-wide importance of this research is shown by the support given by British Telecommunications Research Establishment, which has sent six scientific officers and a large amount of technical equipment to this country.

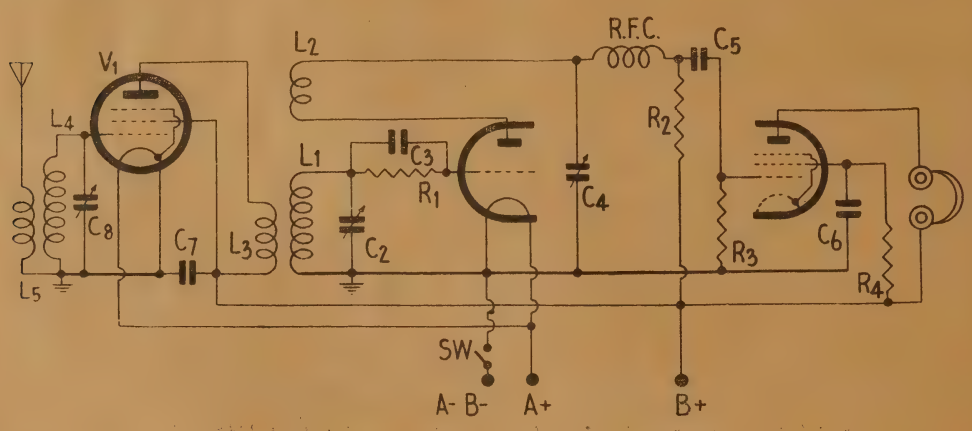
The chief personnel who have been appointed are: Chief Scientific Officer, R. S. Unwin, D.S.I.R., N.Z.; Chief Scientific Officer (U.K. Team), B. Milnes, TRE.; Chief Radar Officer, J. P. Conyers-Brown, R.N.Z.A.F.; Chief Meteorological Officer, R. W. James, D.S.I.R., U.K.; Chief Analysis Officer, H. Davies, T.R.E.; Radar Officers, W. S. Joyner, T.R.E., A. D. Bates, T.R.E., H. Drysdale, T.R.E.

Training with the equipment in the meteorological trucks and the installations of ship and aircraft equipment is well under way. Observations are expected to commence shortly, when "Radio and Electronics" will keep readers informed as to progress and general information relating to the project.

THE RADEL "PROGRESSIVE" BATTERY THREE

PART III.—CONVERTING TO THE TUNED R.F. STAGE

In Part II of this series we outlined the advantages to be gained by adding an ant. stage of R.F. to a regenerative detector. Briefly, the isolation provided by the untuned stage gives (1) more stable control of regeneration over the wave bands covered by individual coils, (2) prevention of the detuning of signals by the swinging of the aerial, (3) prevention of radiation by the oscillating detector, and (4) the addition of some gain.



$C_1 = 30\mu\mu f.$ max. trimmer.
C_2, $C_8 = 0.00035\mu f.$ max. variable.
$C_3 = 0.0001\mu f.$ mixed.
$C_4 = 0.0003\mu f.$ max. variable.
C_5, C_6, $C_7 = 0.1\mu f.$
$V_1 = 1N5\text{-}GT.$

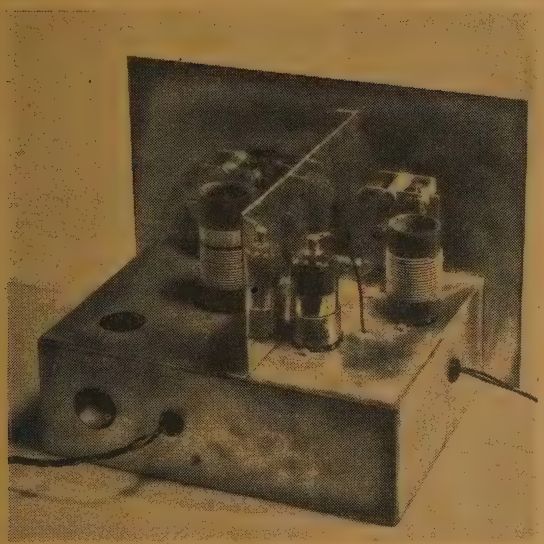
$R_1 = 2$ Megs.
$R_2 = 50{,}000\,\omega$
$R_3 = 5$ Megs.
$R_4 = 20{,}000\,\omega$
$R_5 = 10{,}000\,\omega$
R.F.C. = 2.5 mh. choke.

In addition to these desirable features, the tuned R.F. stage has the great advantages of providing extra selectivity, and about five times as much gain as the untuned stage. Normally, if the expense is not too great, a tuned R.F. stage is a far better addition to the regenerative detector than an untuned stage, but in this set, more especially for the benefit of the less experienced constructor, we have urged the case of the untuned stage, because it is an inexpensive and worth-while proposition. At the same time, it needs no special skill to get going properly. However, once the untuned stage is constructed, very little extra effort is required to turn it into a tuned stage.

THE CIRCUIT

Reference to the circuit of the Progressive Three in its third stage shows that the circuit is very little different from that of the untuned stage. Now, instead of the resistor-choke arrangement in the grid circuit of the 1N5-GT, we have a tuned circuit L_4, C_8, and the aerial is coupled in to this through the primary winding L_5. No changes are required in the detector coil windings, which remain exactly as before.

The tuning condenser C_8, for the R.F. stage has the same value as the one used for C_2, so that it is a simple matter to "track" the two tuned circuits. In this set no attempt has been made to gang C_2 and C_8, but it is an advantage if the coils are matched closely enough for the settings of C_2 and C_8 to correspond fairly accurately when both are tuned to any station. Separate tuning control for the R.F. stage has the advantage of ensuring the best possible results on all stations, for there can be no "tracking error" to reduce the set's sensitivity at some places on the dial. Forty-five volts on plate and screen of the R.F. stage has been retained for



this step of the construction, as with this no R.F. gain control is necessary. Strong signals can be weakened, if desired, by detuning the R.F. stage slightly to one side or the other of the proper tuning point.

CONSTRUCTION

If the set has been built so far exactly according to specifications, very little work is needed to place the R.F. stage in operation. First of all, a baffle-shield (shown in the photograph) is necessary now that the R.F. stage is to be tuned. If this is not added, there is more than a possibility of the R.F. stage oscillating, due to coupling between the R.F. and detector coils. The shield shown is made of sheet aluminium, and is 7in. long by 4in. high. Along one of the long and one of the short sides are ½in. flanges, which are used to fix the shield to the chassis

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and front panel respectively.

Before the shield is fixed in place, the mounting holes for C_8 should be drilled in the chassis, and also the hole for the lead from the coil socket to the stator of the condenser. If the wiring of the coil socket was made according to the directions in Part II of this series, the only wiring necessary is to connect the wire from the condenser stator to pin No. 1 on the coil socket. Then, when the R.F. coils have been constructed, all that is necessary is to plug them in and switch the set on.

CONSTRUCTION OF R.F. COILS

These coils are made exactly as for the detector coils, except that this time a four-pin valve-base type of plug is used for the base of the coil. The aerial coils are wound exactly as was described for L_3 in the last instalment. Coil specifications for the R.F. coils are as follows:—

Broadcast:

L_4 105 turns 36-gauge en. close wound.

L_5 20 turns same wire, wound over bottom end of L_4.

Short-wave A (approx. 30-90m.):

L_4 16 turns 24-gauge en. or D.C.C. double spaced.

L_5 5 turns 36-gauge en. inter-wound at bottom of L_4.

Short-wave B (approx. 19-60m.):

L_4 6 turns 24-gauge en. or D.C.C. double spaced.

L_5 3 turns 36-gauge en. inter-wound at bottom of L_4.

The winding should be terminated on the pins of the plug as follows: Pin No. 1, top of L_4; pin No. 2, bottom of L_5; pin No. 3, top of L_5; pin No. 4, bottom of L_4.

OPERATING THE SET

The R.F. stages gives one more control which has to be set, but this offers no difficulties. With the coils as specified, settings for both tuning condensers will almost coincide when both are tuned to a station. If the detector is made to just oscillate, and the R.F. tuning control is rotated, static, ignition noise, etc., will come in loudest at the correct setting of the R.F. dial. With the latter set, it is possible to explore about 10 degrees on either side with the detector dial without too much loss of gain. When a carrier is located, the R.F. dial can be brought into tune for best results, and the detector and reaction controls finally adjusted. The set now is extremely sensitive, and will give really excellent DX results, particularly on shortwave. If first-class headphone reception *only* is desired, the set as it stands takes a lot of beating.

THE FINAL STAGE

The final stage of the Progressive Three describes how the 1D8-GT is removed from its present position, and used as two stages of audio, capable of exciting a speaker. A separate triode is used in the present 1D8 socket as the detector, and the set is provided with 90 volts of B battery, and R.F. and audio gain controls. It thus ends up as an extremely versatile battery receiver, capable of good DX performance on phones or speaker, and giving four-valve performance from only three valves.

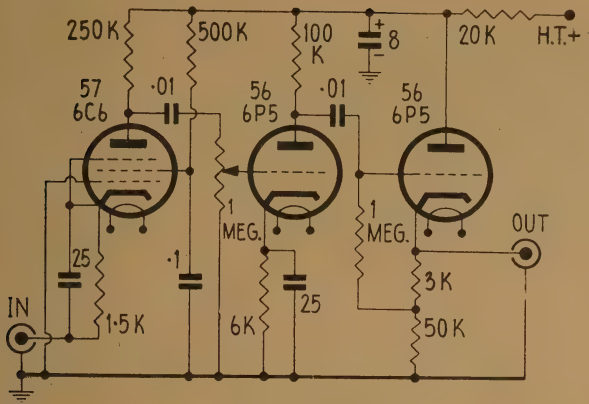
QUESTIONS and ANSWERS

Mr. L. B. Berg, Feilding writes: "I have a 30-ohm dynamic microphone which feeds into a preamplifier and thence to the main amplifier consisting of 6C5, 6J5, and class AB1 6L6s. I am unable to get sufficient gain from the pre-amplifier, except by using transformer coupling, which introduces a high percentage of hum. At the moment I am using two 56s. resistance coupled, but the arrangement has not enough gain. In addition, the microphone is cathode-injected into the first stage. Can you let me have a circuit of a preamplifier which is silent, will match my microphone, and preferably uses 2.5-volt tubes?"

Since Mr. Berg is using two 56 type tubes in a resistance-coupled circuit with 100k. plate loads, the overall pre-amplifier gain will be approximately 100, but this is stated to be insufficient. In the circuit given by Mr. Berg, the output is taken straight from the plate of the second 56 via a condenser-resistor combination. This, and the fact that he was using transformers in order to achieve sufficient gain, is enough to account for the high hum level encountered. We are pleased to print here our recommended circuit, but it should be remembered that hum-free operation of a low-level pre-amplifier depends as much on proper construction as on the circuit used. The use of a cathode-follower output stage is sufficient to eliminate induction hum which would otherwise arise as a result of the high output impedance. However, since in our circuit about ten times as much gain is used as in Mr. Berg's circuit, care must be taken to prevent power supply hum from affecting the pre-amplifier. The following precautions should be taken therefore:—

(1) Both output and power supply leads should be shielded, preferably in separate cables.

(2) A separate filament winding should be used for the pre-amplifier tubes, and this winding



High-gain, low-hum preamplifier circuit suitable for a dynamic microphone.

should be grounded through the moving arm of a 100-ohm potentiometer connected across the winding at the transformer and adjusted for minimum hum.

(3) The whole pre-amplifier should be completely enclosed in an iron box.

(4) On no account should the heavy H.T. decoupling shown in the circuit be omitted.

The cathode injection has been retained as being the best method of connecting a low-impedance microphone without the use of a transformer. No actual matching exists between the microphone output impedance and the input impedance of the first valve, but this does not matter, as we are interested only in voltage and not power gain.

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It employs the Model F3 meter, fitted with a specially calibrated scale, clearly marked to indicate low values of resistance on one scale, and higher values of resistance on an alternate scale. The instrument is powered by an internally fitted 1.5-volt cell.

Ranges and operating instructions are clearly indicated on an etched metal plate, and on the meter face, so that the instrument can be operated by unskilled personnel.

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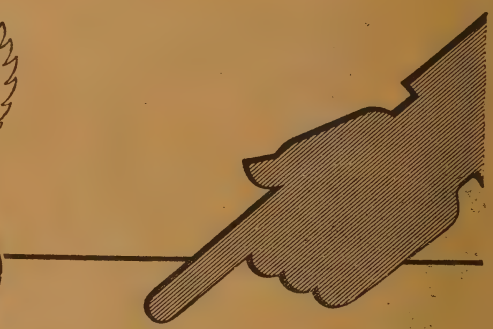

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OUR GOSSIP COLUMN

Ian Hansen, of Beacon Radio, Auckland, has been in Wellington for a few days on behalf of his company. Ian was engaged on radar during the war, and, while serving with the Royal New Zealand Air Force, saw service in England and the Pacific. On returning to New Zealand, he was appointed Officer Commanding R.N.Z.A.F. Electrical and Wireless School, Wigram, during which time he held the rank of Squadron Leader. On release from the Service he accepted an appointment with Beacon Radio as design engineer.

* * *

Shades of spring were obvious in Papatoetoe a few weeks ago when Bill Caskie and his team were seen splashing a lovely variety of new paint over the Caskie edifice. This reminds us, Bill, that Ralph Slade of Philips would be a useful man to contact if you need any advice on painting! Since painting the roof of his home, Ralph has become an authority on Newton's Law of Gravitation.

* * *

A prominent Oamaru personality is Mr. G. T. Gillies, principal of G. T. Gillies & Co., Ltd.

Business activities of this concern do not lack variety—main interests being Hydro Electric Developments, Radio and Electrical equipment, and G.M.C. trucks ex W.A.R.B.

The Radio Department is ably handled by Doug Heinz who, for health reasons, has taken up residence in Oamaru. Doug will be remembered by many for the good work he did in setting up the splendid service department now maintained by Wilkins & Field, Nelson. During the war years Doug directed his attention to the manufacturing side of radio, being with the Special Apparatus Section of Messrs. Collier & Beale, Ltd., Wellington.

* * *

Rua Clarke, of Crisps Music Shop, Gisborne, has got himself organised into civilian life after a spell in the Armed Forces. 'Tis said that his ambition at the moment is to break 150 on the popular Poverty Bay links.

* * *

Ralph Slade, of Philips Electrical Industries, has been in Christchurch on production matters, and whilst there contacted Robert Francis, Ltd., Direct Supply Co, and N.Z. Farmers' Co-op.—all good Philips dealers. They have reported good sales, which indicates that Ralph had plenty to say about the overseas supply position.

* * *

George Ovenden, of Hughsons N.P. Hardware H.M.V. dealers of New Plymouth, called in to see us a few weeks ago. George is Manager of Hughsons' Radio Department, and was in Wellington for a few days checking up on the stock position. Hughsons also handle Phonomatic inter-communication sets for Green & Cooper, Ltd.

What spare time George has when not selling H.M.V. or waiting for washing machines to arrive, he spends yachting as co-skipper of the Z-class yacht, "Fleet."

* * *

Phil Stebbings, of Stebbings Sound Systems, Auckland, called on us recently. He came from Auckland with the Friendly Road Show to do the sound work, and brought his own equipment with him. Phil has been pretty well occupied of late in setting up the sound systems at the Auckland Wharf during the arrival of troop ships.

* * *

Recently joined Green and Cooper, Ltd., Wellington, is "Tubby" Mahood. "Tubby" went overseas early in the war while serving with the R.A.F. After going through the R.A.F. Radar School, he specialised on A.I. night-fighter radar equipment. Don Cooper, a partner of the above firm, was also a radar "type" in the R.N.Z.A.F. After an extensive technical course he became an instructor at the Radar School in Yatesbury, England.

* * *

Mr. A. E. Poll, Managing Director of Philips Electrical Industries, has just returned to New Zealand after a combined business and holiday trip to Sydney, Melbourne and Adelaide. Mr. Poll was Manager of the Adelaide Office some years ago, so he was able to renew many old acquaintances.

* * *

Doug Hall, who during the war years was with the Radio Development Laboratory, is now head of the Electronics Laboratory at the Dominion Physical Laboratory. Doug has had a wide experience in all types of radar, and will be a useful man when the Department's radar programme gets under way. Two radar newcomers to the Lab. are Frank Evison, ex-R.N.Z.A.F., and Don Fenton, ex-Navy.

* * *

Paul Baillie, Manager of Fears Radio Department travelled to Auckland by air recently and spent several days discussing general business matters with members of the Queen City radio industry.

* * *

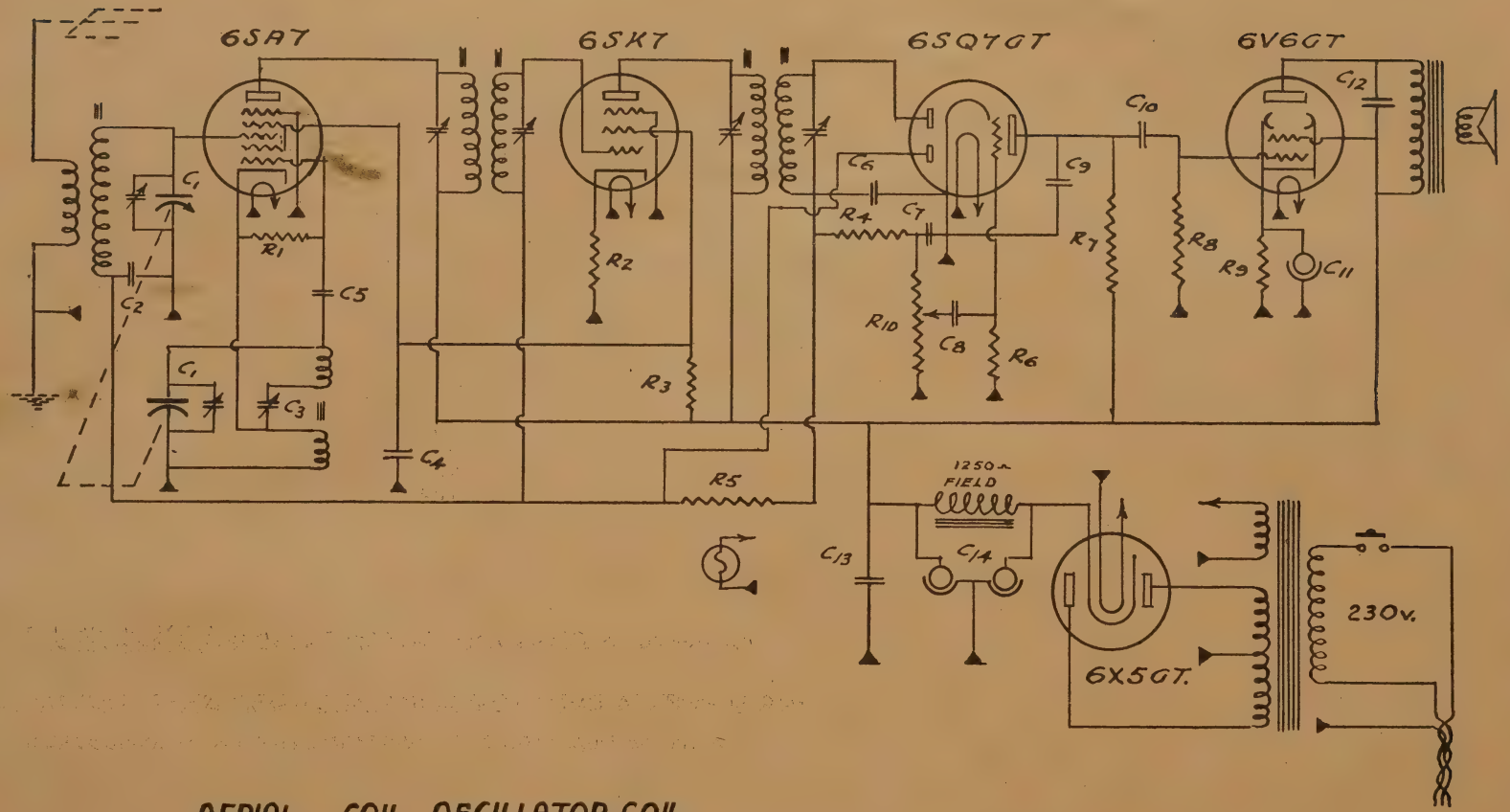
Arthur Bradley, of Bradley's Electrical Co., was suffering from a severe cold a few days ago, which resulted in a complete loss of voice. Bill Neighbours, of Wellington Electronics, was not very sympathetic, his only comment being, "Now I know what a Fohn wind is!"

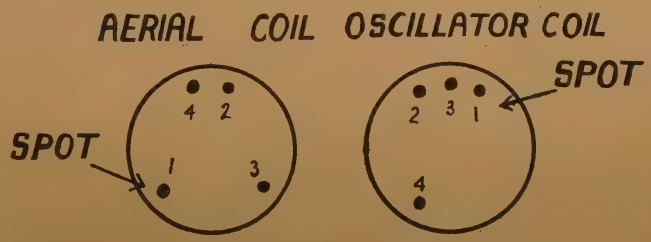
* * *

Ken Schollum, Christchurch Manager for Swan Electric, has been combining business with pleasure in the North Island. The primary purpose of his trip was to attend his sister's wedding, after which he took the opportunity of calling on the Swan Auckland and Wellington offices.

For the Serviceman—PHILIPS RADIOPLAYER, MODEL 540

INTERMEDIATE FREQUENCY = 455 Kc/s.





RESISTANCE AND CONDENSER VALUES.

CONDENSERS		RESISTORS	
C1	2 Gang Tuning.	R1	22,000 Ohms ½ Watt.
C4	.05 MFD 200V.	R2	47 Ohms ½ Watt.
C5	56MMFD.	R3	3,900 Ohms 1 Watt.
C4	.06 MFD 200V.	R4	50,000 Ohms ½ Watt.
C5	56 MMFD 200V.	R5	2.2 Megohms ½ Watt.
C6	100 MMFD.	R6	5.6 Megohms ½ Watt.
C7	100 MMFD.	R7	.5 Megohms ½ Watt.
C8	.01 MFD 400V.	R8	.47 Megohms ½ Watt.
C9	400 MMFD.	R9	600 Ohms 1 Watt.
C10	.01 MFD 400V.	R10	.5 Megohm Vol. Control.
C11	25 MFD 25V.		
C12	.01 MFD 400V.		
C13	.1 MFD 400V.*		
C14	10 + 10 MFD 450V.		

*This condenser is not normally included in the receiver.

VOLTAGE TABLE

Valve	Plate	Screen	Cathode	Heater
6SA7	175	115	—	6
6SK7	175	115	0.8	6
6SQ7	50	—	—	6
6V6	170	175	10	6
6X5	240 Volts AC per Plate		240	6

The voltages given in this table apply when a voltmeter of 1,000 ohms per volt is used, and no signal input to receiver. Variations in voltage readings up to 10 per cent. are permissible.

COIL CONNECTIONS

Types { 469.30x—Red Spot
{ 469.30 —White Spot
Aerial Coil ..... 1—2
6SA7 Grid Coil 3—4

Types { 471.11x—Green Spot
{ 471.11 —Blue Spot
Grid Coil ..... 1—2
Cathode Coil ..... 3—4
1st I.F. Transformer (Type VK476.02)
6SA7 Plate Coil: Blue—Red
6SK7 Grid Coil: Green—White/Green Tracer
2nd I.F. Transformer (Type VK476.03)
6SK7 Plate Coil: Blue—Red
6SQ7 Diode Coil: Green—White/Green Tracer

A Fault caused by the "Magic Eye"

If for any reason the cathode of a magic eye tube is more positive than that of the 2nd detector or A.V.C. diode from which the eye is actuated, the magic eye will draw grid-current. The latter will build up a small negative potential on the A.V.C. line, thus reducing the maximum sensitivity of the set.

The trouble should not occur with sets that have been designed to include a tuning-indicator tube, but may easily be encountered when fitting one to a set that was without one before.

The important thing to note is whether the cathode of the A.V.C. diode is at earth potential or not. If so, the cathode of the eye tube may be grounded without much fear of this fault developing. If, as in some delayed A.V.C. circuits, the cathode of the A.V.C. diode is a few volts positive, the magic eye tube cathode must be connected to a point on the circuit at least as positive as this. Since these tubes are not very constant in their characteristics, a heavy bleed current is advisable in a bleeder network to which the cathode is attached. Perhaps the most economical way of doing this is to use part of the output stage's bias resistor—say 20 ohms—at the grounded end, and attach the cathode of the magic eye tube to this point.

Centering Gramophone Pick-up Armatures

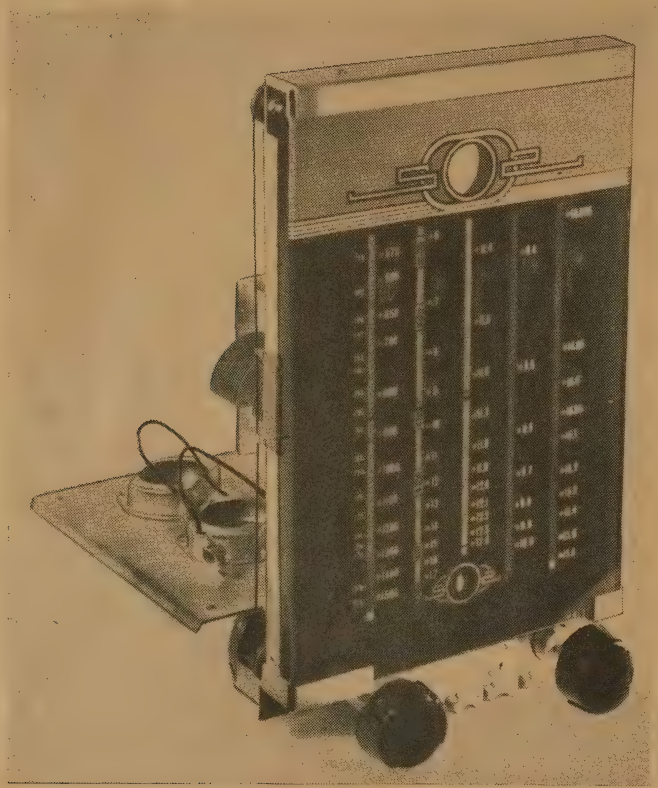
A prevalent trouble with magnetic pick-ups is that the armature becomes off centre, resulting in heavy distortion, especially at low frequencies. Here is a simple test to ascertain whether this fault is present.

With a record playing in the normal way, place the fingers lightly on the pick-up head and press gently downwards, at the same time moving the head slightly to left and right. If the armature is off centre, the distortion will be less obvious with the head pressed one way, and will often become worse with the pressure in the opposite direction.

Do not try this with a good record, as the side pressure may damage the groove walls. Normally the armature is held in place by a clamp, and rubber pads, and the latter lose their resilience, so that the remedy in this case is to replace the pads with new pieces of suitable dimensions, taking care to see that the armature is correctly centered during the process.

In replying to advertisements in Radio and Electronics please mention our name—it helps us both.

NOT JET PROPELLED ——— BUT JUST AS NEW!



THE DE LUXE BAND SPREAD TUNING UNIT

PRICE:

Unit only	£10-7-6
Chassis	12/6
Complete Kit	£20-19-6
Kit for Push-Pull output	£22-19-6

(LESS SPEAKER)

(retail only)

THIS TUNING UNIT represents the greatest advance ever made in coil assemblies for home constructors. The bands covered are broadcast and short wave ranging from 16 to 49 metres. The remaining three scales give full calibrated band spread coverage of 19, 25 and 31 metres. Another important feature is that the complete unit is aligned and sealed before leaving the factory, thus eliminating one of the home constructor's greatest bug-bears—that of alignment without suitable instruments.

Obtainable only from

S.O.S. Radio Service

283 Queen St. Auckland

S.O.S. RADIO SERVICE,
283 Queen St., Auckland
Please sent to me full information on the De Luxe Band Spread Tuning Unit.

Name .....

Address .....

Town .....

A Practical Beginners' Course

PART 4

In Part III last month, we described the working of the tuned circuit that is a part of the crystal set, and of all other sets, too. We explained in simple terms why it is that a particular electrical size of tuning coil is required if we are to tune in any broadcast stations with a particular tuning condenser. In addition, we described how the performance of the simple set of Fig. 1 could be improved by adding an aerial coil, giving the circuit now shown in Fig. 3. If, in the meantime, you have made this addition to your crystal set, you will have noted some differences between the performance of the two circuits.

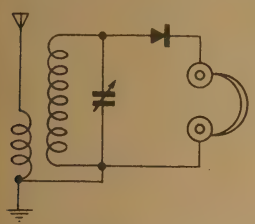


FIG. 3

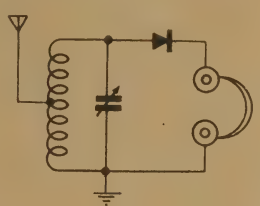


FIG. 4

LIMITATIONS OF THE SET

Now we are in a position to examine our very simple set and find out what improvements might be desirable in it. Those of you who have built it will have obtained very different results according to where you live, and, could you compare notes with someone else who has built the set, you would soon find this out.

SELECTIVITY

In a good many towns, there is more than one local radio station. For instance, in Wellington there are 2YA, 2YC, 2YD, and 2ZB. If a set is to be at all effective, one must be able to tune in any of these stations simply by turning the tuning-knob, and the set should be able to give good volume on each of them when it is properly tuned in.

Now, since a crystal set gives only the amplification of the tuned circuit (and we have no control over this), the loudness of the various stations received will depend entirely on the strength of their signals at the receiving aerial. This, in turn, will depend on where you live, and on the power of the transmitting stations. Because of these things some stations will be heard much more loudly than others, and it does not follow at all that the most powerful stations will be heard loudest. In fact, if someone had a crystal set close enough to, say, 2ZB on Mount Victoria, it might not be possible to hear any other station at all. However, in this case, 2ZB and 2YD transmitters are in the same building, and their frequencies are not very far apart. You can check on this by taking a look at your ordinary radio set and observing the exact place on the dial on which these stations should tune in. If, then, you are very close to both these stations, the chances are that, with our crystal set, you will hear both 2ZB and 2YD at the same time. You will probably find that, at some positions of the tuning condenser, 2YD will be louder than 2ZB, and at others the reverse will be the case, but at no setting is it possible to tune in one station without hearing the other in the background.

This state of affairs is very annoying when both stations are on the air and you desire to listen to either of them. When a set performs in this manner, it is said to have insufficient selectivity. Thus, we can say that **selectivity** is that quality of a set which enables it to receive one signal only out of all that may be present in the aerial.

Our description of the working of a tuned circuit is perfectly selective, but, as experience with the set shows, this is not the case. Although it does attempt to select one station, it does not always manage to. This is because no tuned circuit is perfect. Some are better than others, but even the best coil and condenser arranged in a single tuned circuit will not give high enough selectivity to allow us to separate stations which have nearly the same frequency, and so are found close together on the dial of the set. This is one of the main reasons why valve sets contain many tuned circuits, each one giving added selectivity.

DE-TUNING

In our set we have simplified things as much as possible by connecting the aerial directly to one side of the tuned circuit. In one way this is a good thing, because it gives us larger and therefore louder signals than do some other arrangements, but such a connection has a very noticeable disadvantage. It is this. Although the aerial is only a piece of wire stretched out fairly straight and not wound round a former, it acts in some ways just like a coil. That is to say, it has **inductance** just as a coil does. In actual fact, although it may not look like it, it has **capacity** also! Because of this, connecting it to our tuned circuit alters the tuning just as effectively as does turning the condenser shaft. This is very unfortunate, since no two aerials are the same, and a short aerial will have a smaller effect in this way than will a long one. The effect of connecting the aerial is the same as if we had wound our coil with more than 70 turns of wire. The longer the aerial, the more turns we can think of as having been added. It is fairly obvious now, that, although we have carefully made our tuned circuit of the right electrical size to tune in 2YA with the condenser almost closed, the moment we connect the aerial 2YA immediately wanders off, so that we have to turn the condenser leaves outwards to tune it in properly. Worse than this, any station which should tune in with the condenser nearly all the way out will probably have disappeared altogether!

By this time, you will have realised that our delightfully simple crystal set is not nearly so good as it might be, even if we could say that aerial Gremlins were the cause! Luckily, however, there is a cure for both lack of selectivity and for the wandering of stations, or **de-tuning** as it is properly called, which is caused by the aerial.

OTHER METHODS OF IMPROVEMENT

The method described in Part III of improving the selectivity of the simple set by adding an aerial coil is only one way out of the difficulty. Other ways of achieving the same results can be used, and will prove just as effective, but before we go on to describe some of these, a little experimenting with aerial coils is in order, for it will show us just what is the effect of various types of coil.

First of all, why did we use 30 turns for the first aerial coil? Would 20 or 40 turns have been more effective? Our next experiment will help us to answer these questions. In it we will change our set from the circuit of Fig. 3 to that of Fig. 5, so, for a start, let us see what this new circuit means. In Fig. 5 we still have an aerial coil, but it looks rather different from the one in Fig. 3. The short horizontal wires running out from the coil are called **tappings.** That is to say, every so often, as we go upwards from the earthed end of the aerial coil, a small piece of wire is soldered to one of the turns, just as is shown in the diagram. When this is done, it is possible to connect the aerial to any one of these tappings or connecting points, so that we may have five, 10, 15, 20, etc., turns between the earthed end of the coil and the tapping point to which the aerial is connected.

The small arrow drawn on the end of the aerial wire indicates that this may be connected to any of the tapping points, according to taste. It can be seen that now currents from the aerial flow, not through the whole aerial coil, but only through that part of it between the tap which is being used and the earthed end. No aerial current can flow from the tapping through the upper part of the aerial coil, since the top end is not connected to anything, so that, for all practical purposes, the portion of the aerial coil above the tap which is being used can be considered absent. In this way, a tapped coil provides us with a rapid means of altering the electrical size or inductance of the aerial coil without having to wind a fresh coil every time we want to try a different inductance.

CONSTRUCTION OF THE TAPPED COIL

The construction of the new tapped aerial coil is not at all difficult, but requires a certain amount of care. So as not to waste the wire used for the original untapped aerial coil, we will use this over again. First of all, remove the coil from the set by unsoldering the circuit, as the winding job is much easier to manage with the coil removed from the set. Next undo the top end of the old aerial coil and attach it to a suitable fixed point, such as a door-knob or the picket of a fence. Now, unwind the coil by walking away with the former, keeping the turns tight and allowing the wire to unwind as you go. Do not allow the coil to slip off the former, because it is very difficult to straighten it out without putting kinks in it. Unwinding it in the reverse way from which it was wound prevents this altogether, and the wire may be used again.

Do not unwind the whole coil, but stop when there remain five turns counted from the lower end. This is where the first tapping is to be. Holding the five turns tightly on the former with the left hand, carefully scrape the insulating cotton from about an inch of the wire. Doing this needs care, as the cotton tends to fray, leaving more wire exposed than is wanted. When, say, an inch of the wire is bare, make a sharp bend in the centre of this bare piece and twist the double bit so obtained until you have a bare twisted piece about half an inch long. A pair of pliers can be used to do the twisting, and will make the job much easier. When the twisted piece has been made, wind on another five turns past the twist and make another one. This forms the second tapping point. After the first twist has been made, you will have to be careful not to pull the wire too tight when continuing the winding, or the twisted bit will tend to straighten out. The right tension to use can easily be gauged after a

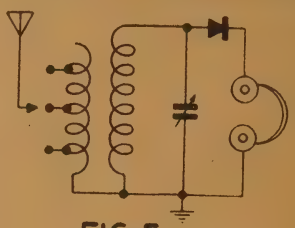


FIG. 5

trial, and there will be no difficulty in keeping the turns quite tight, at the same time keeping in the twisted tappings. Carry on in the same manner, making a tapping point every five turns until all the wire is used up. Then, fix the end as has been done before, and the tapped coil is made. In order to finish it off properly, it is advisable to coat the bare twisted tapping points with solder. This is quite easy to do, as the bare wire is very bright and clean, and a dab from the hot iron and a piece of resin-cored solder will "take" immediately. The purpose of this is to prevent the tappings from unwinding when they are in use and allowing the coil to become slack. It is a good plan, after soldering the taps, to give the whole aerial coil a coat of shellac varnish. This fixes the coil in position very well, and it can then be treated quite roughly without any danger of its coming undone.

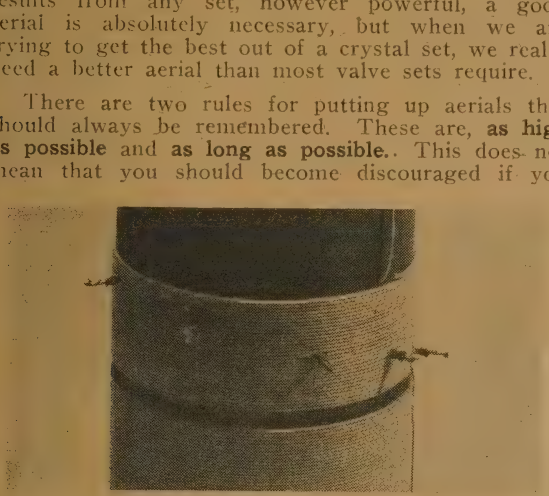
After the new aerial coil has been wound in this way, the coil former is replaced on the base board and connections are made as in Fig. 5. The best plan for connecting the aerial to the various taps is to mount a separate Fahnstock clip on the base board for an aerial terminal and screw down with it a small solder lug. To this lug is soldered a piece of wire about six inches long, to the free end of which is connected an "alligator" clip. This clip can then be attached to any of the aerial coil-tapping points. The aerial lead is connected to the Fahnstock clip in the usual way. This is much more convenient when the set is in use than having the alligator clip directly on the end of the aerial lead.

ERECTING AN AERIAL

Now that we have proceeded thus far, it is time to consider putting up a good outside aerial. If you are very close to a station, loud signals can be got from this one (if from none of the other local stations) by having as an aerial only a piece of

wire inside the room. However, if you wish to receive as many stations as possible, the only kind of aerial to have is a good outdoor one. For best results from any set, however powerful, a good aerial is absolutely necessary, but when we are trying to get the best out of a crystal set, we really need a better aerial than most valve sets require.

There are two rules for putting up aerials that should always be remembered. These are, **as high as possible** and **as long as possible.** This does not mean that you should become discouraged if you



This picture shows the tapped aerial coil at the top of the tuning coil. Note how the tappings are spaced round the former so that they do not come too close to each other. This is done simply by allowing about an inch extra after each five turns has been wound on, before the twist is made in the wire.

cannot put up a wire that is very high and long, for almost any sort of aerial erected outside will give satisfactory signals from at least one station. Obviously, very few people are in a position to put up an aerial 50 feet high and a hundred or more feet long, but the rules simply mean that if you **can** do this, you should, if you want the best results.

When choosing a spot for an aerial, try to find one which is shaded by the house as little as possible. If you cannot put up two masts, try to put up at least one, as far from the house as possible, and take the aerial from the top of the mast to the highest convenient point on the house, such as the base of a chimney or to a hook screwed in to the wall just under the spouting.

An aerial need not be made of heavy, so-called "aerial wire." It is better to be made of this if possible, but just as good results can be obtained by using the same kind of wire as you used for making the coil for your set. This is light, easy to erect, and is cheap. For example, if you have bought a half-pound reel (which is much cheaper than buying small hanks as are sometimes sold), you will have plenty left to put up as long an aerial as you can find space for. The chief trouble with using this is that it cannot be pulled too tight for fear of breaking it, and that, in time, it will stretch. However, if it does, it is a simple matter to pull it tight again. For insulation, all that is needed are a couple of small "egg" insulators at each end. The insulators should be tied together with a piece of rope used as a halyard, and need be only a few inches apart.

Letters to the Editor

Since our September issue, when we printed in our "Questions and Answers" column a reply to a question which asked for advice on the design of a special broadcast receiver suitable for DX purposes, we have received a number of letters from readers wishing to signify their interest in this project, and requesting *Radio and Electronics* to publish a suitable design. Among these is one from Mr. Sydney Stevens, of Takapau. In his letter, which is too long to print in full, Mr. Stevens makes a number of suggestions for features which he would like incorporated. They are:—

(1) An R.F. stage using either a 6AC7/1852 or an EF38 for purposes of increasing the signal-to-noise ratio.

(2) A separate oscillator.

(3) Control of oscillator amplitude.

(4) Two I.F. stages.

(5) Bandpass tuning in the first I.F. stage. (It is not quite clear what is meant by this, but we suspect variable selectivity.)

(6) A direct-coupled audio circuit.

(7) A.V.C. circuit using separate valves. (Presumably to provide amplified A.V.C.)

While *Radio and Electronics* does not necessarily agree with all these proposals, we are very pleased to have Mr. Stevens's suggestions. For the benefit of those who have already signified their interest, work is now proceeding on the design of this receiver. Since, at this stage, the actual arrangement has not been rigidly fixed, we take pleasure in inviting our readers to submit suggestions as Mr. Stevens has done for design features which could be usefully incorporated. In evolving the final design, all such suggestions will be given due consideration, so that the set may meet DX-ers' requirements to the fullest possible extent.

When replying to advertisements in **Radio and Electronics** please mention our name—it helps us both

TRADE WINDS

1896 — B.T.H. — 1946

The fiftieth anniversary of the British Thompson-Houston Co., Ltd., was celebrated in May, the company having been formed on May 18, 1896, from an organisation which had developed from the original London firm of Laing, Wharton & Down, which started trading in 1886. The celebration, therefore, is actually that of a double jubilee.

It is interesting to trace the early developments both in America and in England, but, very briefly, it may be said that the Thomson-Houston partnership really began in America about 16 years before the present company was formed in England. Elihu Thomson was an Englishman born in Manchester in 1853, who settled with his parents in Philadelphia and at the age of 23 became Professor of Chemistry and Physics in the Central High School. E. J. Houston, who was born in Alexandria, Virginia, in 1847, was a colleague at the same school and eventually became Professor of Natural Philosophy there.

The Two Professors Join Churchill

An American named Churchill, of New Britain, invited these two Professors to join him in forming the American Electric Co., which later became the Thomson-Houston Electric Co., and, eventually, the General Electric Co. (of New York, U.S.A.).

The connection of the Thomson-Houston Electric Co. with England commenced in 1886, when the firm of Laing, Wharton and Down was formed to exploit in Great Britain the sale of apparatus made by the Thomson-Houston concern in America. During these eventful early years of electrical development, foundations were securely laid for the subsequent growth of the B.T.H. Co. to the world-wide organisation as it is known to-day.

Start of Manufacturing

The first sign of actual manufacture was the formation of "British Thomson-Houston Ltd." in 1894. This new company no longer acted merely as agent, as it had purchased the existing patents of the American company with the exclusive right to manufacture or to have manufactured, and to sell machinery and apparatus under these patents in Great Britain and Ireland. In May, 1896, the name was changed to "The British Thomson-Houston Company, Ltd."

During the first year or so of the B.T.H. Co.'s existence the only manufacturing facilities were at a small works and store at Bankside, London, but many pioneer electric lighting, tramway, and railway installations were undertaken. At this time the B.T.H. Co. carried out the contract for the power station, substations and electrical driving equipment for the trains on the new Central London Railway ("Twopenny Tube"). In the multiple-unit system adopted, the control equipments were placed near the motors which were mounted at various points along the train, and were all operated by the driver from the front of the train. This was the system which first led to the use of electrically-operated contactors for railway service, and the B.T.H. Co. has now supplied multiple-unit equipments for electric railways all over the world.

25 Acres, now 120, and Many Other Works

The need for greatly increased manufacturing facilities becoming evident, some 25 acres of land at Rugby was purchased in January, 1900, and manufacturing commenced on March 14, 1902. These works were planned at that time for about 800 operatives, and consisted of 14 steel and brick buildings with a total floor space of about 206,000 sq. ft.

Prior to the building of the works, the company's business was conducted almost entirely from London, but in October, 1901, the majority of the staff moved to the Head Office at Rugby, which became the headquarters for engineering, manufacturing and commercial matter, the Registered Office of the company remaining in London.

On the sure foundations laid the various departments have ever developed and expanded under such far-sighted guidance as is associated for instance with the names of W. C. Lusk, H. N. Sporborg, F. Fraser, R. Dumas and F. Samuelson, to mention but a few. To-day the Rugby works occupies 120 acres on the original site, while there are other works at Coventry, Willesden, Birmingham, Chesterfield, Peterborough, Nelson, Newcastle-under-Lyme, Colne and elsewhere.

The country is covered by a network of District Offices, while the company has offices, or representatives, in most of the countries of the world.

Emphasis on Research

Research has always been an important part of the B.T.H. organisation, and many of its contributions to knowledge under the direction of R. C. Clinker and H. Warren (now managing director of the company) are well known and, it is safe to say, its work will be of no less importance under the present Director of Research, L. J. Davies.

The jubilee year of the B.T.H. Co. finds it in the throes of the changeover from war to peace conditions. Men and women who were in the forces are returning to the company and are resuming again their industrial life. Many alterations in organisation are taking place, and an entirely fresh outlook is being unfolded both at home and in the export field. The splendid organisation built up during the past half-century is now in the hands of younger men, headed by Mr. Warren.

Forward to the Next 50!

The B.T.H. Company faces the next 50 years with increased strength and confidence.

The following are the present directors:—Sir Felix Pole, chairman; Sir George Bailey, deputy chairman; H. Warren, managing director; E. H. Ball, G. M. Campbell, I. R. Cox, L. J. Davies, H. A. Lingard, E. S. Little, A. A. Pollock, J. S. Ramsden and W. W. Vinsen.

* * *

ALLUM ELECTRICAL CO., LTD., HOLDS STAFF CONFERENCE

A conference of the staff of the Allum Electrical Co., Ltd., was held in Auckland during the week-end, September 20-23. The meeting was presided over by the Managing-Director, Mr. J. A. C. Allum, and was attended by the executive and sales staff. The Managers of the southern branches, Mr. R. W. Allum, Wellington, Mr. F. T. McKeogh, Christchurch, and Mr. A. G. Edey, Dunedin, arrived by air and the

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The Hohner inter-communication system is an attractive instrument housed in a rugged metal case and crackle finished in grey or black. The electrical construction is well engineered to ensure long trouble-free service. The system is designed to accommodate any number up to twelve out-stations, six being the standard, and is also provided with one switch position to call "all stations" if required. The Hohner Electrical Company is now in a position to appoint representatives. Consequently it is suggested that dealers who are interested should write without delay to . . .

HOHNER ELECTRICAL CO.

11 HERBERT STREET **WELLINGTON**

(P.O. Box 192 TE ARO)

series of discussions which took place were of great benefit to all concerned.

In addition to considering matters of policy, many aspects of electrical and radio developments were covered and the decisions arrived at will be reflected in the near future, in the association between the company and its many business friends throughout the country.

* * *

PHILCO LICENSES R.C.A. TO USE ITS RADIO PATENTS

In a step of far-reaching importance to the entire radio industry, Philco Corporation has licensed the Radio Corporation of America to use the Philco Advanced F.M. System and approximately 600 other Philco patents and inventions relating to radio and television receivers and electrical phonographs, it was announced recently by John Ballantyne, president. Philco also stands ready to grant non-exclusive licenses to other radio and electronic concerns, Mr. Ballantyne said.

"The agreement just concluded between Philco and the Radio Corporation is the first general patent license issued by our company and covers the results of almost 20 years of research and development work in the field of radio and television," continued Mr. Ballantyne. "One of the most important inventions covered in the agreement is the new Philco Advanced F.M. System. This is an entirely new system of frequency modulation (F.M.) detection which is considered one of the fundamental advances in the radio art. Advanced F.M. offers the important advantage of greater clarity in reception because it ignores natural and man-made noise, and also a marked gain in fidelity due to its uniform response over the whole audible range.

"The technical progress in radio, television and electronics in recent years is extraordinarily great, and with our research and engineering facilities increased and strengthened, Philco is desirous of co-operating with others in the radio and television industries to share the fruits of its research. Such co-operation was practised energetically during the war to speed victory, and the new licensing agreement with R.C.A. represents the first translation of that spirit to commercial operations."

* * *

BRADLEY'S ELECTRICAL CO., LTD.

A firm which has enjoyed rapid progress is Bradley's Electrical Co., Ltd. Established in 1941, "Abec" had its factory at Kilbirnie, Wellington, and specialised in transformers, motor rewinding and element manufacture. The end of 1941 saw the firm well under way with ten employees, and in the second year "Abec," in addition to normal production, undertook the manufacture of radio equipment for the Armed Services. During its third year, the original factory space of 800 square feet was increased to 3,500 and the staff rose in number to 35.

In 1945 "Abec" realised the importance of decentralisation with the result that the plant and automatic machinery was moved to a new factory in Masterton —the factory area now being 10,000 square feet. The Head Office and showroom was opened in Victoria Street, Wellington, and the headquarters now concentrates on the sales and service section of the business.

"Abec" now has a staff of over 50 employees, including many who were trained in the technical sections of the Armed Forces. The manufacturing division, which specialises in the production of domestic appliances, sound equipment and electronic devices, conducts its own technical lectures, and from the recreational aspect has organised its own sports teams.

"Abec" is headed by Messrs. A. Bradley, Managing Director, G. F. Richardson, Secretary, B. Terry, Sales Manager, K. McEwen, Manager of the Manufacturing Division, and J. Butt, Production Manager.

* * *

S.T.C. INTRODUCE R.F. HEATING

Plastic manufacturers will learn with interest that S.T.C. Megatherm R.F. Heating Units are at present in New Zealand.

S.T.C. Megatherm Dielectric Heating Units are a means of supplying heat to substances which are electrical insulators not through the surface of the material but right in, and uniformly throughout it. The value of this ability is appreciated when the plastic moulding process is examined.

By supplying presses with preheated powder or preforms the outputs of costly presses can be increased considerably with the resultant article produced being better in every respect through uniform heating.

The preheating of plastics is by no means the only application in which dielectric heating has proved advantageous, and among its other uses are extreme dehydration and sterilisation of foods both loose and packaged, plywood manufacture and elaborate and

Any further information on S.T.C. Megatherm previously impossible chemical processes.
R.F. Heating Units may be obtained from Standard Telephones and Cables Pty. Ltd.

WIDE-BAND AMPLIFIERS

(*Continued from p.* 12.)

unsuitable for use where very great band-width is required, and pentodes are used instead.

With a pentode stage, the load resistance Rl is always very much less than rp, and may be as low as desired without doing anything worse than reducing the voltage-handling capacity. Pentodes also give very little Miller effect when compared with triodes, so that, for wide-band amplifiers, they are the logical choice.

(*To be continued.*)

Classified Advertisements

Rates are 3d. a word, with a minimum charge of 2/-. Advertisements must be to hand in this office not later than the fifteenth day of the month in order to be published in the issue appearing about the middle of the following month.

While all care will be taken, no responsibility can be accepted for errors. Advertisements should therefore be submitted either typed or printed in block letters.

FOR SALE, One Four-valve Amplifier, complete, £9; one 5in. E.M. Speaker, 30/-; one 10in. E.M. Speaker, 15/-.—Priest, 26 Woolcombe Terrace, New Plymouth.

Printed by HARRY H. TOMBS LTD., 22 Wingfield Street, Wellington, N.Z.

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